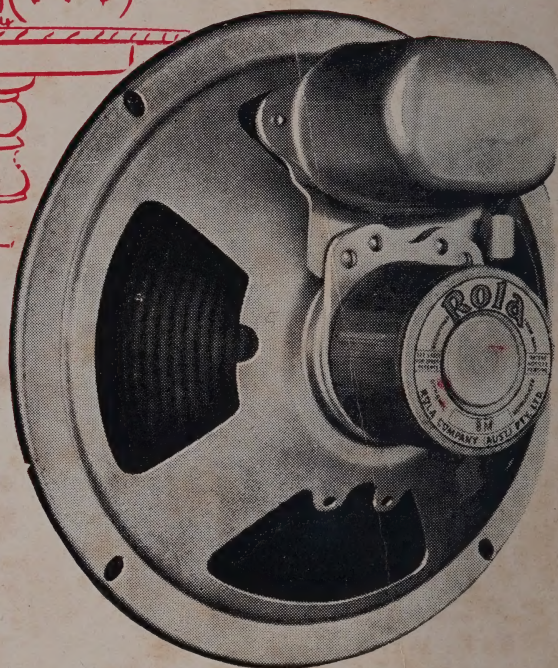
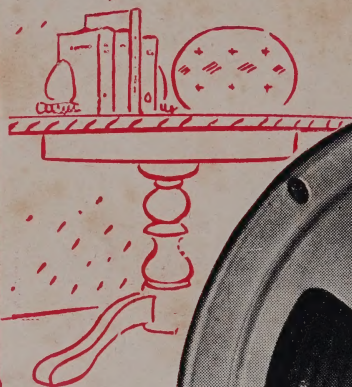
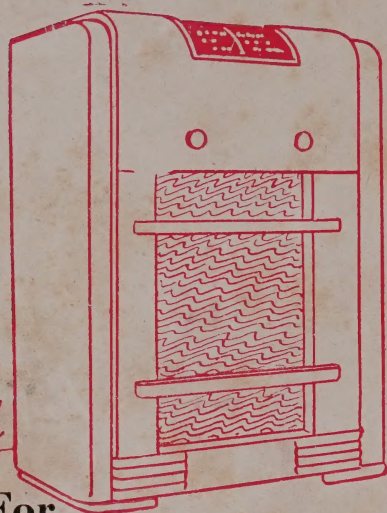


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RADIO and ELECTRONICS

Vol. 4, No. 4

June, 1 1949

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OUR COVER:

This month's illustration is of the "Radel Broadcast Four," whose circuit, construction, and alignment are described in this issue.

Owing to circumstances beyond our control, it has been found impossible this month to continue the usual instalment of "A Practical Beginners' Course."

CORRESPONDENCE

All correspondence, contributions, and enquiries referring to advertising space and rates should be addressed to:—

The Editor,
"Radio and Electronics,"
Box 22,
Government Buildings P.O.
WELLINGTON.

OFFICES AND LABORATORY:
Radio and Electronics (N.Z.) Ltd.,
46 Mercer Street, Wellington.

TELEPHONE:
Wellington 44-919.

AUCKLAND REPRESENTATIVE:
Mr. J. Kirk,
No. 11 Keans Building,
150 Queen St., Auckland.
Telephone 48-113. P.O. Box 401.
AUSTRALIAN DISTRIBUTORS:
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Remittances from Australia to New Zealand should be by international money orders or bank draft payable in New Zealand.

Sole Wholesale N.Z. Distributors FEATURE PRODUCTIONS LTD., P.O. Box 5065, Wellington.

Printed in New Zealand by H. H. Tombs, Ltd., Wingfield Street, Wellington.

BROADCASTING AND THE RADIO MANUFACTURER

Experience the world over has shown that there is a good deal to be said on both sides of the controversy over public or private control of radio broadcasting. Not that the problem is quite as clear-cut as that, since public control—and private, too—can each take a number of forms. Each form of each system has its advantages and disadvantages, and it would be a wise man who could decide, once and for all, which kind of system is the best.

There is one interested party, however, who rarely comes into the public eye except as a simple purveyor of goods, and that is the manufacturer of domestic receivers. He is vitally interested, or should be, in the progress and practice of broadcasting in the countries which constitute his market, but in very many cases he has no say at all in ordering the affairs of broadcasting. This is not so in America, where many large manufacturers very early undertook the broadcasting business themselves, presumably on the principle that by doing so they were increasing the size of their market for their own goods. There, where all is commercial, the same problems as confront our manufacturers do not occur. For instance, on the face of things, it would seem rather unlikely that the set manufacturer should suffer because broadcasting coverage is inadequate. One suspects that the reverse is rather the case.

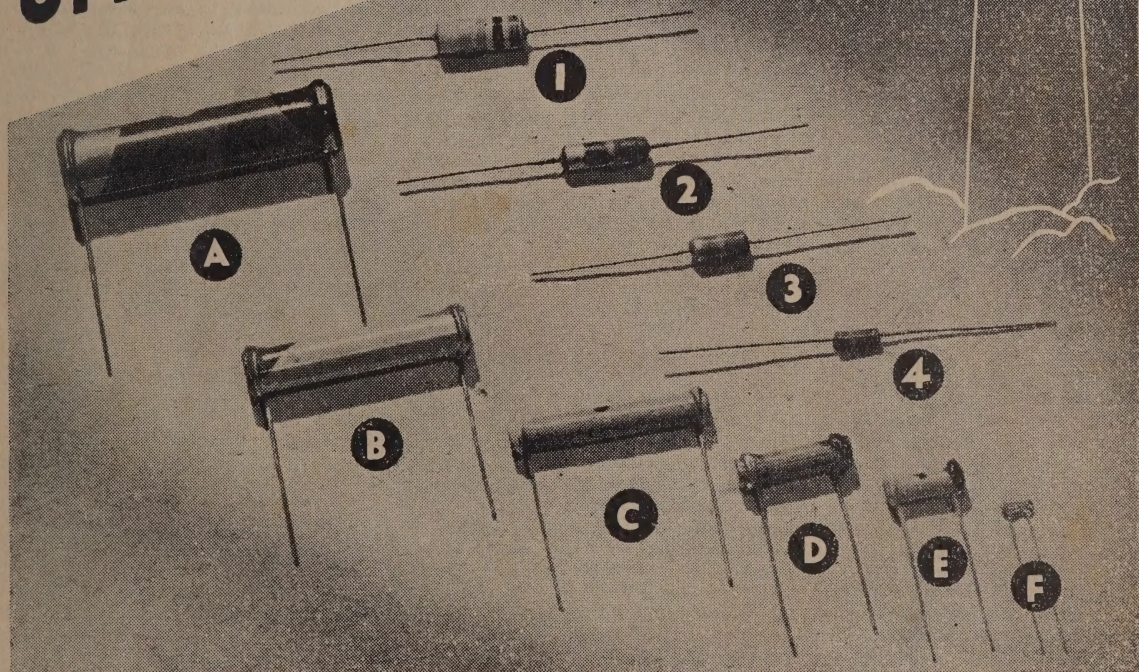
Here, however, the radio industry is concerned—and reasonably so—because there still remain areas in which the coverage can not be described as anything but poor. True, the New Zealand Broadcasting Service is taking rather vigorous steps to remedy this state of affairs, and many new stations are being built. These will effect an enormous improvement, but the fact remains that there are some who say that a better distribution of these new stations could have improved matters still further. It is certainly open to question whether the decision to place new stations in that area or in this were taken as a result of a comprehensive field-strength survey. We are, of course, open to correction in this, but, apart from a fairly comprehensive survey of the coverage of 2YA and 2YC as they then were, there has been nothing of the kind undertaken by the N.Z.B.S. For one thing, some of the previous deficiencies of our coverage were sufficiently glaring for no field tests to be needed, so that their lack does not necessarily mean that any populated area will have been shabbily treated on that account. But estimates, however carefully made, can not replace scientifically-made measurements, and it is quite possible that had a coverage survey been made before the new stations were sited, certain areas would have been found to be better and others worse off than anyone had suspected.

If the manufacturers are concerned about the coverage that obtains over some of the country, they can make—and probably have made—representations to the authorities and placed their views before them, but if this has been done and nothing has come of it, it is clearly a case where one man's opinion is as good as another's. If the Manufacturers' Federation feels that the matter is important enough, there is no reason, apart from finance, why it, as a body, should not undertake a field survey. If this were done and the results published, it could not but benefit the manufacturers themselves, the listeners, and the Broadcasting Service—provided, of course, that the authorities could be persuaded to act upon its findings. If any deficiencies of previously unsuspected magnitude were uncovered, it would be natural for the Broadcasting Service to make use of the information in further implementing its expansion programme, which is still a long way from completion.

The question of whose job it is to do such work hardly arises; if sufficient importance is attached to it, the manufacturers, as a body, should be able to foot the bill, with the knowledge that not only would they stand to benefit from it, once completed, but also that they would be rendering a great service to a substantial portion of the community.

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Picture Telegraph Equipment in New Zealand

It is only a short time since the first commercial picture-telegraph equipment was put into service in New Zealand. For some time now, the Post and Telegraph Department has been receiving pictures sent by radio telegraph, the last link being between Australia and here, and which completes the chain of picture transmission facilities between Great Britain and New Zealand. The principles used in the radio picture service are similar to those employed in sending pictures from Auckland to Wellington over a wired link, there being no fundamental difference at all. The installation of such equipment in this country is just another illustration of the way in which our institutions (in this case the Press) keep up to date by installing the most modern aids to the provision of speedy service to the public.

OPERATING PRINCIPLE

The principle on which picture telegraph and radio picture transmission equipment works is basically the same as that of television. The gear, however, is very different. This difference is accounted for mainly by the fact that in television, an image (i.e., one complete picture) has to be transmitted in the very short time of one-twenty-fifth of a second, whereas in the transmission of still pictures, time is not so important, and it is possible to take many minutes over the transmission and reception of a single image, which is a still photograph. Because of this lack of urgency, the information contained in the picture can be transmitted as quite low-frequency modulation, in the case of radio transmission, or simply as low-frequency tones directly sent along the line in the case of wired transmission. In television, it is fundamentally due to the large amount of information that must be conveyed in a very short time that the modulation frequencies must be as high as several megacycles per second. Because of this, television signals can not be transmitted along ordinary telephone lines at all, and also, when transmitted by radio, they must be used to modulate a V.H.F. transmitter. In the transmission of still pictures, however, a low-frequency carrier may be used, in radio transmission, or ordinary telephone lines, in wired systems, such as the one which now links Auckland and Wellington.

The principle used in transmitting the picture is that of scanning, whereby the picture is effectively broken up into a very large number of separate parts, each of which is transmitted separately, in a particular order. At the other end, the receiving equipment has means both for recording the information sent out by the transmitter, and for setting it down in the correct places, so that, after the transmission is over, the result at the receiving end is a reproduction of the picture which is dissected by the transmitter.

If we imagine a picture as being made up of a very large number of minute squares, of different brightness, then it is clear that the job of the transmitter is to send out a signal which represents, in the order of their sending, the brightness of each of these squares. Thus, the signal sent down the line represents the brightness at different parts of the picture. The ordering of the information, so that the receiver can know which part of the picture the signal refers to, is done simply by scanning the area of the

original, at the transmitter, in a specified and regular manner. The usual practice is to start at one corner of the picture and travel horizontally across it in a straight line. This scanning is done by a photoelectric cell, which, as it moves, sends out a signal which depends at all moments on the brightness of the picture at the point where the cell is "looking" at that moment. When the cell has scanned the top "line" of the picture, it is made to move rapidly back to a position just under the starting point, and from there it scans the picture once more, transmitting the brightness information as it goes. This process goes on until the cell has explored the whole picture surface.

While this is going on, the signals, picked up at the receiving end, are made to modulate the output of a spot of light, in accordance with the brightness information transmitted. At the same time, the spot of light is made to go through the same evolutions in space as the photoelectric cell does in scanning the original picture. By this means, the receiver's light spot records the brightness information sent to it, on a piece of photographic material, and in lines exactly corresponding to those scanned by the transmitter. Thus, the breaking up of the picture at the transmitter is exactly reversed in the receiver.

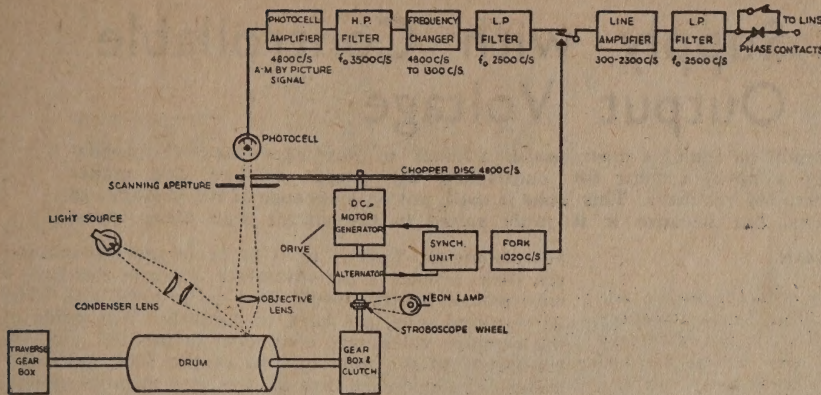
The block diagram shows the set-up of the component pieces in the Muirhead-Belin portable picture telegraph equipment. This is typical of the type of arrangement used in this kind of gear.

The picture to be transmitted is wrapped round a cylindrical drum, which is rotated at very constant speed by a special synchronous motor of exceptional speed accuracy. The drum is slowly rotated at either one or two revolutions a second, and while this is going on, the light source and photoelectric cell are traversed much more slowly along the cylinder in a direction parallel to its axis. The rate of travel can be adjusted so that the picture is scanned at a rate of either 100 or 1500 revolutions of the drum for every inch the light and cell travel along it. This gives similar numbers of scanning lines per inch of picture. The traversing motion of the light and P.E. cell is linked mechanically with the revolution of the drum, so that this rate, too, is governed by the synchronous motor.

It is interesting to note that the A.C. which operates the synchronous motor is generated internally by a precision tuning fork, so that no reliance is placed on the mains frequency, as a speed control. The receiver, too, has its own tuning fork, and such is the constancy of these forks that, once the two are adjusted to synchronism, preparatory to sending a picture, they hold their frequencies accurately enough for the duration of the picture, without any adjustment, and without any interconnecting means of locking one to the frequency of the other.

PHOTOCELL OUTPUT AND THE OPTICAL SYSTEM

The light source has associated with it a lens system which focuses the light to a small spot, which shines on the surface of the picture. The reflected light from this spot is received by a second lens system, and passed through a slit, or scanning aperture, to the photocell cathode, thereby causing



the output current of the photocell to vary in accordance with the brightness of the place on which the spot is focused. Since the movement of the drum is quite slow, the varying photocell current would be composed largely of very low-frequency components, of the order of a few cycles a second. This would cause difficulties in the design of the amplifying equipment, and so a simple but effective dodge is

made use of to allow the light variations to be amplified at higher frequencies. It is to use a light chopper between the drum and the photocell. This chopper is simply a perforated disc, which breaks up the steady light beam at a rate of 7,200 c/sec. The variations in light intensity which are the picture signal are then transmitted as variations in amplitude of this 7,200 c/sec. carrier. The frequency range to be handled by the amplifiers is then a very narrow band centred on 7,200 c/sec., and this frequency can be handled by amplifiers using ordinary audio technique. However, for transmissions over long distances, by telephone line, this is rather too high a frequency, since ordinary, undoctored, long-distance lines are designed to handle up to only about 3,000 c/sec. Because of this, the signal channel of the

(Concluded on page 43.)

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INTRODUCTION

A power supply whose output voltage can be adjusted to any desired voltage, within limits, irrespective of the load that it is supplying, is an extremely useful piece of equipment, and one which we are sure very many of our readers will have felt the need for. Unfortunately, the only circuits that have so far appeared, that have been capable of performing this valuable trick, are the series-regulator type, in which a number of 2A3's, or similar high-current valves are placed in series with the output of the supply, and have their internal resistance varied by means of a control valve, usually in conjunction with a cold-cathode regulator tube of the VR150 series. Unfortunately, such circuits are quite costly to build, and are capable not only of being set to a range of voltages, but of automatically regulating the voltage of the power supply, to take care of the variations of load resistance, or of A.C. input to the power transformer. This is often more than is required, and it is a great waste to have a circuit capable of exact regulation when all that is needed is a means of varying the output voltage. Also, these circuits do not give a very wide range of output voltage variation, and the minimum voltage obtainable is often higher than 200 volts.

The sort of job we are about to describe is one which can give a variable output voltage from, say, 40 or 50 volts, up to something like the maximum possible from the power transformer and rectifier used.

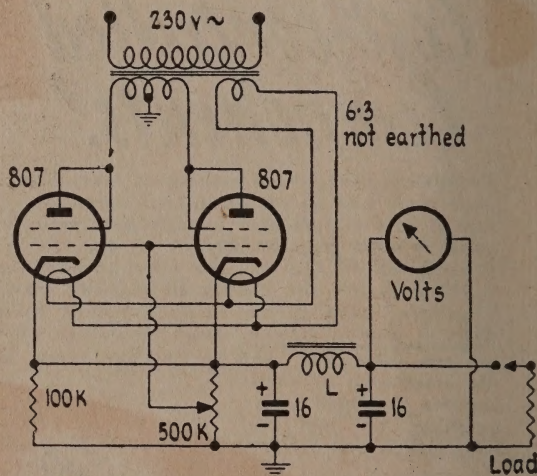
In the accompanying circuit this is brought about by using two 807's as RECTIFIERS, and in such a way that their voltage drop can be adjusted, thereby adjusting the power supply's output voltage. The number of extra components, compared with a normal power supply, are quite few. The normal rectifier valve is dispensed with and the 807's are used instead. The only extra component worthy of note is the heater transformer for supplying their 6.3v. heaters, it not being possible, of course, to use the 5v. winding normally used for the rectifier. The smoothing filter is just as usual, and can be constructed with one or two sections, as desired, regardless of the usual rectifier circuit.

CIRCUIT

It can be seen at the outset that the 807's are connected as triodes, with their screens tied to the plates. This saves a certain amount of complication straight away, as no arrangements for feeding a separate voltage to the screens have to be made. The cathodes are tied together, and if we ignore the connections that are made to the control grids, it is seen that the circuit is simply that of an ordinary full-wave rectifier.

Now for the grid circuit. A small permanent load resistance of 100,000 ohms is placed across the output of the rectifier, and in parallel with this is a 500k.

potentiometer. This is used in preference to making the 100k. resistor a potentiometer, since in this case a wire-wound control would have to be used, and 100k. wire-wound pots. are hard to come by. The grids of the rectifier valves are connected in parallel, and are connected to the moving arm of the 500k. potentiometer. The grids are thus always at a negative potential with respect to the cathodes, so that there is no danger of their becoming positively biased at any stage and running the valves into grid current. When the arm of the potentiometer is at the earthed end of its travel, there is a large negative bias on the grids, and this increases the internal resistance of the tubes. The output voltage is therefore reduced. Clearly, this position of the control gives the highest negative bias, and therefore the lowest output voltage. At the other end of the scale, the control sees that the bias on the rectifiers is zero, and therefore that their internal resistance is a minimum. Under these conditions, the voltage output is a maximum.



This is only a very brief description of the manner in which the circuit functions, but is sufficient to enable anyone, however inexperienced a constructor he may be, to understand its action sufficiently.

A proper investigation of its workings would be quite a complex affair, and would have to take into account the fact that the input to the grids is not D.C., but has the waveform typical of that seen at the reservoir condenser of any condenser-input filter. Thus, the valves' resistance varies somewhat over the A.C. cycle. Also, there is the fact that the A.C. is applied, as it were, in push-pull to the plates, while the grids have the filtered waveform applied in parallel.

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Perhaps it should be mentioned that the scheme will never enable zero output volts to be obtained. The table given later in this article shows that the lowest voltage obtainable depends on the load resistance, and is lower the heavier the D.C. load placed on the supply.

TRANSFORMER VOLTAGE AND PERFORMANCE FIGURES

In order to demonstrate what most readers will want to know about the circuit—namely, just what sort of voltage variation can be expected under different conditions of D.C. load, we arranged a test circuit, using a 400-volt-a-side power transformer. To obtain the performance figures, particular values of D.C. load were connected across the output, and the maximum and minimum voltages attainable with that load resistance were measured.

Someone is sure to ask why this inconvenient method was used instead of giving the figures for stated values of output current. It is this, that the difficulty is to get a specific output current at the particular settings of the control that we want to talk about. This would have to be done by using a variable load resistor of very high wattage, if the results were to be taken in anything like a reasonable time. However, to give some indication of the current capacity of the supply, we have listed the maximum current that it will push through any particular load resistor. For instance, at a load of 2000 ohms, the circuit shown gave a maximum voltage of 270, at a current of 135 ma. Thus, for a current of 135 ma., the maximum voltage that can be got from the circuit without using a higher voltage in the transformer, is 270. Likewise, if the greatest current

that will be taken from it is 82.5 ma., then the maximum voltage that can be got at this current is 330v. At smaller current drains, the available voltage will be higher.

Load Res.	Output Min.	Volts, Max.	Max. Output Cur.
2k.	50	270	135 ma.
4k.	52.5	330	82.5 ma.
8k.	57.5	390	49 ma.
12k.	60	415	34.5 ma.
16k.	62	440	27 ma.
Inf.	70	510	0 ma.

At the lower end of the scale, working out Ohm's Law to find the current drain corresponding to the load resistances and minimum voltages shown in the table, shows that with a 2k. load, the minimum current is 25 ma. With an 8k. load, the minimum current is 7.2 ma., and the minimum voltage has risen to 57.5. In other words, the lower the output current required, the **higher** is the minimum output voltage.

This is not serious, however, since even at no external load at all, the minimum voltage has risen only to 70.

If lower minimum voltages are needed, they can readily be obtained by reducing the transformer voltage. For example, a 385v.-a-side transformer, other things being equal, can be expected to give an output varying from 35 to 55 volts, depending on the current required at the same time. The maximum output voltage will also be reduced by this change, but there is nothing that can be done about this. Fortunately, where low minimum voltages are wanted, high maxima will not usually be wanted at the same time, so that little difficulty should occur.

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A Modification to the Radio and Electronics Panoramic Adaptor

In our issues of January, February, and March, 1949, we described the circuit and construction of a panoramic adaptor suitable for amateur construction. In the light of further operational experience with this unit, certain modifications were made which considerably improved its performance, and this short article describes them.

INTRODUCTION

Since the "Radio and Electronics" panoramic adaptor was presented in these pages, operational experience has shown that, as was expected to some extent, the unit could do with more sensitivity than it has in its original form. The original model was therefore modified to include a stage of amplification on the first I.F. of 465 kc/sec., thereby giving the whole set-up rather more amplification than is strictly necessary, instead of not quite enough. This is a far better state of affairs, and one which can be remedied simply by turning down the gain control, whereas, if the gain is insufficient, only some extra construction can improve matters.

THE EXTRA 465 kc/sec. STAGE

The provision of extra gain is most easily tackled by adding a stage on the first I.F. of 465 kc/sec., rather than attempting to add a second stage on 100 kc/sec. The latter would bring in difficulties of stability, since the original circuit and mechanical lay-out was arranged for a single stage. The addition of a stage on 465, on the other hand, does not introduce any difficulty of this kind, since the original circuit did not incorporate a stage on this frequency, and, even with it installed, there is still only one valve amplifying at any one frequency inside the unit.

The extra valve can quite easily be accommodated, since it uses a 6BA6 miniature pentode. As the circuit of Fig. 1 shows, there are very few components apart from the valve itself, especially since the transformer is already there. The valve can be mounted on a small piece of aluminium, say, 1½ in. square, which has a narrow flange down one side, by which it is screwed to the side of the chassis close to the I.F. transformer and the input socket. This is no hardship, as the input socket initially was placed close to the input transformer. The 100-ohm cathode resistor has its other end connected directly to the moving contact of the gain control potentiometer— R_2 on the original circuit diagram. Series screen feed is used to enable the addition to be made with the least possible disorganization of the existing circuit. The abundant bypassing and the plate decoupling resistor should be noted, and should on no account be omitted.

In cases where the adaptor is to be used with two or more receivers (which must have the same I.F., of course), the addition of the 6BA6 has a further advantage in that it gives excellent isolation between the mixer of the receiver and the stagger-tuned I.F. input transformer of the panoramic adaptor. There is then no possibility of the transformer becoming detuned when it is attached to different sets. The transformer is a ticklish thing to adjust properly, and it is a good thing to be able to set it once with the knowledge that thereafter it will not need touching.

It will be seen that the 6BA6 is provided with a

250k. grid leak resistor, and that the 100k. series resistor that was shown on the original unit as R_1 has been omitted. With the I.F. transformers removed from the input circuit of the adaptor, there is no longer any necessity for this, and its omission will still further increase the sensitivity. The blocking condenser at the plate of the mixer in the receiver proper must still be used, of course, although this is not shown in the present diagram. The notes in the original article concerning the installation of the shielded lead from the adaptor to the receiver proper still apply, however.

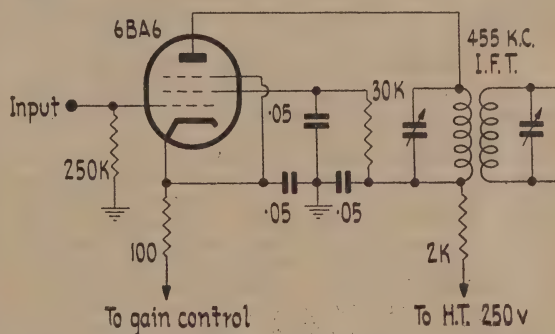


Fig. 1.—Circuit of the additional 465 kc/sec. amplifier stage for the adaptor.

ANOTHER USEFUL ADDITION

A further useful addition, and one which is very easy to make, is to install a phone jack (open-circuit type) on the front panel, and wire it to the output of the Y amplifier, V_0 on the original circuit. Do not forget to insert a blocking condenser; it will also be advisable to add a resistor of 50k. or so in series with the phones. This will prevent the loading imposed by them from reducing too much the amplitude of the deflection on the screen.

The purpose of the phones is to act as an extra check on the arrival of further off-tune signals. For instance, if the gain control of the adaptor is set so that only a few signals are present on the screen, the arrival of an additional one can be heard as a change in the pitch of the somewhat rough note that will normally be heard. The fewer the signals on the screen, the more sensitive will this test be. The phones can also be used to turn the adaptor into a second I.F. channel for the receiver. Usually, the adaptor, with its 100 kc/sec. I.F., will be much more selective than the receiver itself, whose I.F. is 465 kc/sec., unless a crystal filter is in use. It is thus possible to use the adaptor to separate signals that the main set will not, simply by plugging in the headphones and turning off the sweep control, R_{22} . When this is done, the adaptor simply becomes a part of a conventional double-conversion receiver.

WINDING HIGH-FREQUENCY R.F. CHOKES

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On the higher frequency bands (10 metres and up) the amateur is faced with a double problem. Should he use R.F. chokes in the grid or plate or filament circuit, and, if so, what type of choke should be used. The question of "Shall I use an R.F. choke here?" is often answered by looking through circuit designs to see if others used a choke in that place in the circuit. On the other extreme, an amateur may decide not to use any chokes because he has experienced trouble with R.F. chokes causing parasitics.

This indecision on the part of the average amateur is partially caused because he does not understand how an R.F. choke works. Or, if he understands R.F. chokes, he may find that the proper choke is not available commercially. The purpose of this article is to explain briefly how R.F. chokes operate and to give details on how to build good high-frequency chokes.

OPERATION OF R.F. CHOKES

A radio frequency choke is normally used to provide a D.C. path from a point of zero R.F. voltage to a point where R.F. voltage exists.

What magic property is built into R.F. chokes which enables them to pass D.C. currents and yet act as effective barriers to radio-frequency currents? Obviously an R.F. choke must have inductance, capacitance, resistance, or some combination of these three. The answer is found in the word "impedance," which is another way of saying "resistance to radio-frequency current." The inductance, capacitance, and resistance which are present in a choke combine in a certain way at certain frequencies, and it is this combination that is called impedance.

It is not necessary for an R.F. choke to act like a high inductance in order to work properly. Probably the most common R.F. choke is the 2.5 millihenry type with four pies. This type is normally used as a series choke on the lower frequency ham bands.

This type of choke has a relatively high impedance which is due to capacitive reactance. Because this and other types of R.F. chokes which cover a large frequency range are subject to resonant points at certain frequencies, it is wise to use them only in circuits where they have been tried and found adequate.

In high-frequency circuits, R.F. chokes are relatively important. Unfortunately, the standard 2.5 millihenry choke will not serve in most cases, so that special high-frequency chokes are desirable. Because the frequency is high, the chokes become simpler to construct. In fact, single-layer windings are desirable.

In addition to their simplicity, single-layer R.F. chokes have an electrical property which is very desirable. If a choke is designed to be self-resonant at a frequency which is close to the frequency or frequencies of desired operation, the choke will be very nearly a perfect choke in that it will be effectively a pure resistance of a very high value. For example, if a choke is desired for 6-metre work, it might be designed to be self-resonant at 45 mega-

(Continued on page 39.)



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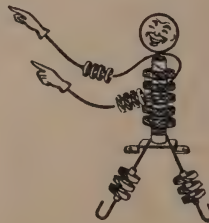
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A Converter for the 144-148 mc/sec. Amateur Band

In the last two issues of "Radio and Electronics" we have published details of transmitting equipment for the lowest of the amateur V.H.F. bands, 144 to 148 mc/sec. Here, we present an excellent circuit for a converter which is very easily constructed, contains only two valves, and has several advantages not usually obtained in simple V.H.F. receiving equipment.

INTRODUCTION

In publishing descriptions of gear for the 144 mc/sec. amateur band, we hope that we have done a little, at least, to encourage amateur transmitters to take up work in one of the most interesting spheres of radio activity—namely, the V.H.F. bands. Perhaps the greatest difficulty that occurs when one attempts to work a V.H.F. band for the first time is that of providing a suitable receiver. There is a great temptation to hurriedly sling together a simple super-regenerative, because of its undoubtedly high sensitivity when properly constructed, but in practice this does not always work out very well, because the super-regenerative receiver is one which is not at all easy to build with the certainty that it IS working properly. The tendency is to assume, with an unknown degree of justification, that the sensitivity is all that may be desired. If it should not be, then much time and effort is wasted in trying to find out why the performance of the system is poor.

Another distressing attribute of the super-regenerative is its radiation, which should only be regarded as a bad thing, even if the band appears to be otherwise unoccupied. All this rather points to the use of a superhet. receiver, especially for one's initial experiments with a new band. If one has a good superhet. at the fixed location, it then becomes an easy matter to conduct tests as between it and a super-regenerative, which might be built for use as a mobile or portable receiver. We are not suggesting that a completely separate receiver should be built for 144 mc/sec., because this would probably run the constructor into more expense than he feels inclined to undergo for purely experimental purposes. The solution, it is felt, is that admirable half-way house, the superhet. converter. The outstanding success with which our 10-metre converter, of venerable memory, was built by a large number of amateurs has prompted us to suggest that a simple job along somewhat similar lines should be the best bet for breaking into the 144 mc/sec. band, and the present article is the result of much deliberation and no little laboratory work.

THE TUBE LINE-UP

It was decided that, in the interests of simplicity, and also because the results obtained on other frequencies indicate that an R.F. stage really is a luxury, if a good mixer is used, to eliminate an R.F. amplifier stage, and instead to start off with a low-noise triode mixer. Even if it is decided at a later date that one cannot do without an R.F. stage, it is a good plan to make the first receiver as simple as possible, and make it work. Now, R.F. amplification at very high frequencies is not the easiest idea to put into practice, and is much better left until, with the converter working properly on its own, the addi-

tion of such a stage, or the re-design of the whole unit to incorporate one, can be an entirely separate problem. In this way, one is much more likely to come to a satisfactory conclusion in a reasonable time than by starting with a design that is really too complex until some experience has been gained.

The first stage, then, is to be the mixer. In order to establish a good signal-to-noise ratio, and so that the performance will leave little or nothing to be desired, even if an R.F. stage is not added later, a triode mixer was decided upon. This brought us immediately to the question of whether the double-triode mixer, using a 6J6, is suitable for use at such a high frequency. It was already known to function excellently at 30 mc/sec. and lower.

The next thing to be decided was whether a stage of I.F. amplification should be built into the converter. If the receiver with which the unit is to be used is a good one, there should be little or no need for an extra stage on the I.F. of the converter. Thus, in line with our policy of keeping the converter as simple and inexpensive as possible, consistent with good performance, it was decided not to build a stage in. This leaves us with the mixer stage, and the local oscillator, as yet unspecified. This is a question which merits special consideration, so we will give it a paragraph to itself.

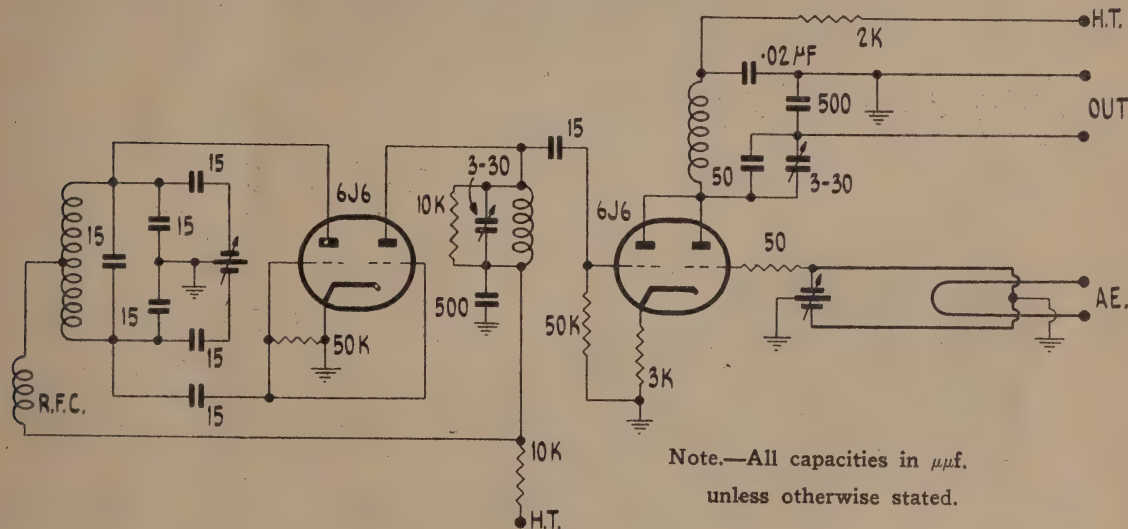
THE OSCILLATOR SECTION OF THE CONVERTER

The difficulty of designing a satisfactory V.H.F. receiver is to a considerable extent bound up with the local oscillator and its behaviour. In fixed-frequency receivers, such as those for mobile V.H.F. services, no tuning controls are allowed the operator at all, so that it becomes necessary to have an "oscillator" consisting of a crystal oscillator, followed by a chain of frequency multipliers, the last of which injects its output into the mixer. This scheme is excellent where stability is the prime consideration, but it is not very helpful if the set has to be continuously tunable over a band, as is the case in amateur communication. We must therefore retain the continuously tunable oscillator, with its potential frequency drift. At V.H.F., frequency drift in the local oscillator has a particularly vicious effect on the performance. The reason for this is that the intermediate frequency is fixed, so that the higher the signal (and therefore the oscillator frequency), the greater must be the stability of the oscillator if constant re-tuning is to be avoided. The I.F. channel is not interested in frequency drift expressed as a percentage of the oscillation frequency, but only in drift of a given number of kilocycles. For example, suppose the I.F. channel has such a bandwidth that an oscillator drift of 5 kc/sec. is enough to cause re-tuning to be required, so that the signal shall still be heard. This figure remains the same whether the signal frequency

is 1000 kc/sec. or 1000 mc/sec. In the former case, the allowable drift would be 0.05 per cent. of the signal frequency, and stability of this sort is readily obtainable with standard valves and components. In the case of the 1000 mc/sec. signal, however, the 5 kc/sec. drift is only one-thousandth of 0.05 per cent. or 0.00005 per cent. of the operating frequency. Stability of this order is exceedingly difficult to achieve, even in a laboratory oscillator whose frequency does not need to be continuously variable, let alone one in which continuous variation is an additional requirement.

All this seems rather frightening, and unless we

Here, we have chosen a still higher I.F.—namely, 14 mc/sec. This was decided upon because (a) it is high enough to give a considerable reduction in the oscillator frequency. This could be either from 158 to 162, or from 130 to 134, in order to give the required 14 mc/sec. beat, so that the latter is the obvious choice. (b) 14 mc/sec. is a frequency for which most amateurs will have a receiver, and in addition is not so high that additional coils cannot be wound for an existing set if necessary. (c) This frequency is high enough for the converter to have quite good image rejection, even without the use of an R.F. stage.

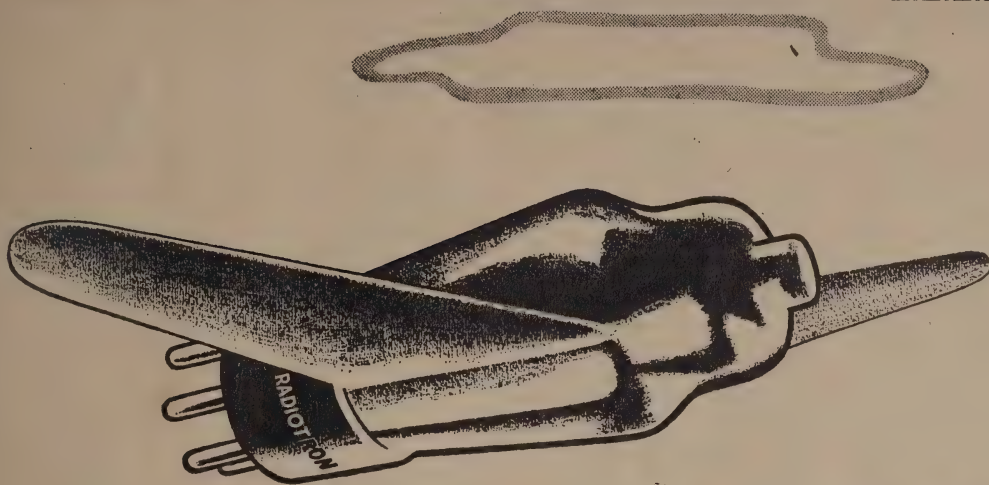


could assure the reader otherwise, might well make him think that a V.H.F. superhet. is a thing to be avoided like the plague! However, things are not always as bad as they seem, and the above illustration was given merely to show that it is somewhat more difficult to get the requisite oscillator stability for a V.H.F. receiver for the local broadcast set. What, then, can we do to relieve the situation a little?

Many high-frequency receivers start to solve the problem by choosing a high value of intermediate frequency. This is a step in the right direction, because it is well known that the higher the frequency of a fixed-tuned amplifier, such as an I.F. amplifier, the less is its selectivity. So, the less the selectivity, the wider the pass-band (which is only another way of saying the same thing), and therefore the more oscillator drift that can take place before the signal has to be brought back by re-tuning. Having chosen a comparatively high I.F., the oscillator is put on the low-frequency side of it, thereby making the oscillator frequency lower than it would otherwise have to be. An example of this practice is to be found in the 10-metre converter published in this journal early in 1946, in which a 4 mc/sec. I.F. was used for a signal frequency of 30 mc/sec., and the oscillator was put on 26 mc/sec. instead of 34 mc/sec. The difference between these two possible frequencies for the oscillator is quite great enough to allow the choice of the lower to have a beneficial effect on the frequency stability.

However, we do not stop here. There is a great deal to be said for the system of using an oscillator-multiplier system instead of a plain oscillator. The most obvious advantage is that the frequency at which the oscillator works is still further reduced, and by a large amount at that, so that it should be possible to realize even better frequency stability by so doing. It is true, of course, that any drift occurring in the oscillator is multiplied in the frequency multiplier, but if the latter is a doubler, the drift is multiplied by a factor of only 2, and the improvement in stability brought about by halving the frequency of oscillation should be better than this, the total result being a net gain.

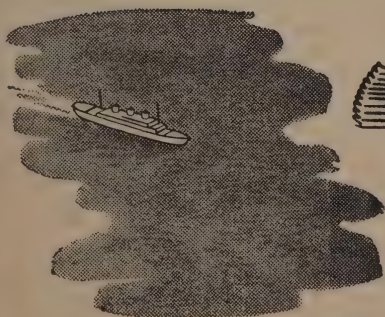
Quite apart from questions of drift, there is another very good reason for using a frequency doubler, especially when the mixer tuning is not ganged with that of the oscillator. It is the old story of oscillator "pulling." This effect is worst when the I.F. is low, so that the percentage frequency difference between the signal and the oscillator is very small. For a given intermediate frequency, pulling becomes progressively worse as the signal frequency becomes higher, so that one cure, or partial cure, is to use as high an I.F. as possible. At frequencies as high as this, however, it would be quite appreciable, even with an I.F. of 14 mc/sec. But when the oscillator works on a sub-multiple of the required mixer injection frequency, and there is a doubler between the oscillator and the mixer valves, pulling is to all intents and purposes eliminated. With the addition of



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This, in conjunction with the 15 $\mu\text{f.}$ series condensers, and the total of 22.5 $\mu\text{f.}$ fixed capacity connected across the coil, gives a quite high-C circuit, for stability, and at the same time gives almost complete bandspread. The oscillator coil has nine turns of 20-gauge wire, wound on a $\frac{1}{2}$ in. former, and with the turns spread to occupy one inch of winding space. This coil will be quite firm, mechanically, if supported solidly at the centre, where the R.F. choke taps on, so that final frequency adjustment can be done by squeezing or stretching the coil slightly. The doubler plate coil consists of three turns of the same wire, wound to the same diameter, and spaced to occupy $\frac{1}{2}$ in. of winding space. Both these coils should be supported by their own wire, with as little lead as possible. The 15 $\mu\text{f.}$ condensers used in our experimental work were very minute silvered-ceramic types, and were soldered directly between the stator lugs on the two-gang condenser and the ends of the coil. The doubler plate coil was mounted only half an inch away from the valve socket, so that it came quite close also to the oscillator coil. To prevent reaction between the two coils as far as possible, the two were mounted at right-angles, and it was found that there was no observable effect on the oscillator, as the doubler was tuned through resonance.

The output tuned circuit consists of a coil of 12 turns of 20-gauge wire on a $\frac{1}{2}$ in. former, tuned to 14 mc/sec by the network of condensers shown. The 0.02 $\mu\text{f.}$ condenser is merely a bypass for radio frequencies from the "cold" end of the tuned circuit, but the 500 $\mu\text{f.}$ in series with the 50 $\mu\text{f.}$ fixed and its trimmer in parallel with it forms a capacity voltage divider which steps down both the voltage and the impedance at the output terminal, making it suitable for connecting directly to the aerial of a receiver.

The input line is made from 14 or 16-gauge bare copper wire. The wires are spaced by $\frac{1}{2}$ in., and are each 12 $\frac{1}{2}$ in. long. A similar type of tuning condenser is used to the one employed in the oscillator circuit, except that its maximum capacity is 17.5 $\mu\text{f.}$ It is mounted just close enough to the mixer tube to allow the 50-ohm grid stopper to be connected between one stator lug and the grid pin with practically no length of lead at all, and the ends of the line are connected to the two stator lugs on the other side of the condenser.

There is no need to make a long attenuated chassis in order to accommodate the input line, since the latter can be bent round and back upon itself so that the short-circuited end can be earthed by soldering directly to the frame of the condenser. The line can then be accommodated in a length of 6 in. or so, or even less, if the wires are bent in a circle. As long as the two wires remain parallel to each other and the two halves on either side of the bend do not come closer to each other than 1 $\frac{1}{2}$ in., no harm will be done.

In order to make the oscillator as stable as possible, it would be preferable to house the complete oscillator-doubler circuit in a small shield box, with the valve mounted on the outside. The purpose of doing this is to insulate the tuned circuit of the oscillator, as far as possible, from the heat produced by the valve. The latter being, as it were, in the fresh air, would itself heat less than if it were totally enclosed or encased in a valve shield, thereby reducing the possibility of drift from heating of

the valve elements themselves. The box could be mounted on top of the chassis, close to the mixer valve, and in such a way that the output lead from the doubler plate circuit can be short. All earths on both the oscillator-doubler circuit and the mixer should be taken to one point on the chassis for each. Since the centre shield-pin on the miniature sockets should themselves be earthed by as direct a route as possible, a solder lug can be mounted on the chassis, close to the socket, and made the common earth point for the stage. As far as the split-stator input tuning condenser is concerned, it is a good plan to mount it on a sheet of insulating material and take a single earth connection from the centre partition straight to the mixer earth point. There will then be no trouble with multiple earth-returns in the mixer grid circuit, especially if the centre-point of the line is also earthed at the centre partition of the condenser, as suggested above.

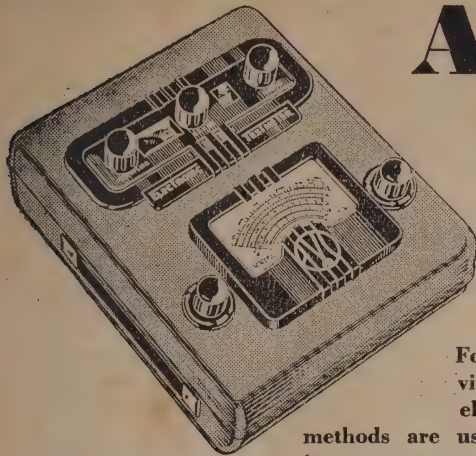
These precautions should all be taken, but this does not mean that if they are not the converter will not necessarily behave itself. If they are taken, however, one can be reasonably well assured that all will be well, and that none of the peculiar behaviour that sometimes characterizes V.H.F. equipment will occur to plague the builder.

SETTING UP THE CONVERTER

When the construction has been completed according to the above recommendations, the setting-up will be found very simple, especially if Lecher lines are used to put the oscillator on the correct frequency. The way to do this is as follows. First, the 10k. decoupling and dropping resistor in the plate feed of the oscillator-doubler tube is short-circuited. This enables quite some power output to be obtained, and certainly enough to partially light a torch-bulb or 150 ma. panel lamp, when this is coupled to the doubler plate circuit. The mixer tube is removed from its socket. Next, the oscillator tuning condenser is set at half-scale, and with the lamp coupled closely to the doubler plate circuit as an indicator, the latter's tuning condenser is tuned until a glow is obtained in the lamp, indicating resonance. With the lamp left coupled to the output so that a glow shows, the Lecher lines are coupled loosely to the doubler plate circuit also. When the shorting bar is manipulated, a position will be found at which the lamp goes out. This is marked, and the shorting bar is slid farther along the line until a second position is found at which the lamp is extinguished. The distance between the two positions is one-half wavelength AT THE FREQUENCY END OF THE DOUBLER OUTPUT. If the distance is measured in centimetres, the frequency in megacycles per second will be given by the simple sum of $f = 300/2L$, where f is in mc/sec., and L is the distance in centimetres. This frequency can then be adjusted to exactly 132 mc/sec. (which is the required injection frequency for receiving 146 mc/sec., the centre of the band) by spreading or squeezing the oscillator coil very slightly, and making a fresh frequency measurement after each change. When the frequency of the oscillator has been set in this way, the short can be removed from the 10k. decoupling resistor.

The next step is to tune the I.F. output circuit to exactly 14 mc/sec. This can be done by tuning the main receiver to this frequency and attaching the converter output to the aerial terminal. This done, the mixer valve is removed, and an ordinary outside

(Continued on page 35.)



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I.F. transformers should be adjusted in the following order: T₄, T₃, T₁, T₂ for maximum output at 460 kc/s.

An input of approximately 30 microvolts should produce an output of 50 milliwatts.

Calibration:

Adjust 1400 kc/s. point with trimmer T₃ and 600 kc/s. point with trimmer T₄. Adjust 1000 kc/s. point by means of iron core 1. Intermediate point should be checked and osc. sect. of gang fanned to correct frequency.

R.F. Alignment:

Adjust 1400 kc/s. by means of trimmers T₁ and T₂ and 600 kc/s. by means of iron core 2. Loop should not need adjusting, as it is unlikely that inductance should vary.

If calibration has been accurate, 1000 kc/s. should be in alignment. Check intermediate points and correct by fanning det. and antenna sections of gang.

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Output current m.a.	30	30	30	50	50	75
Input voltage	6	6	6	6	12	6
Mean input amps.	1	1.1	1.15	3.3	1.8	5.5
Buffer cond. mf.	.009	.012	.01	.003	.003	.007
Rectifier	sync	sync	sync	sync	sync	sync
Pri. res. ohms	0.9	0.61	0.6	0.3	1.12	.124
Sec. res. ohms	540	600	560	620	595	370
Turns ratio	25	28	31.2	60.4	30.2	66
Mounting	clamp	clamp	clamp	clamp	clamp	vert
Efficiency %	57	60	65	65	64	66
Termination	lugs	lugs	lugs	leads	leads	leads
Height	1 $\frac{1}{2}$ "	1 $\frac{1}{2}$ "	1 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	3"
Breadth	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "
Depth approx.	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "
Mounting centres	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	3 $\frac{1}{2}$ "	3 $\frac{1}{2}$ "	—

NOTE.—The use of a Cathode Ray Oscilloscope connected across the whole of the transformer primary winding for fault location in connection with vibrator power supplies is strongly recommended. It is necessary, of course, to see that half the primary winding is not shorted out by a common earth connection on the oscilloscope and vibrator supply being examined.

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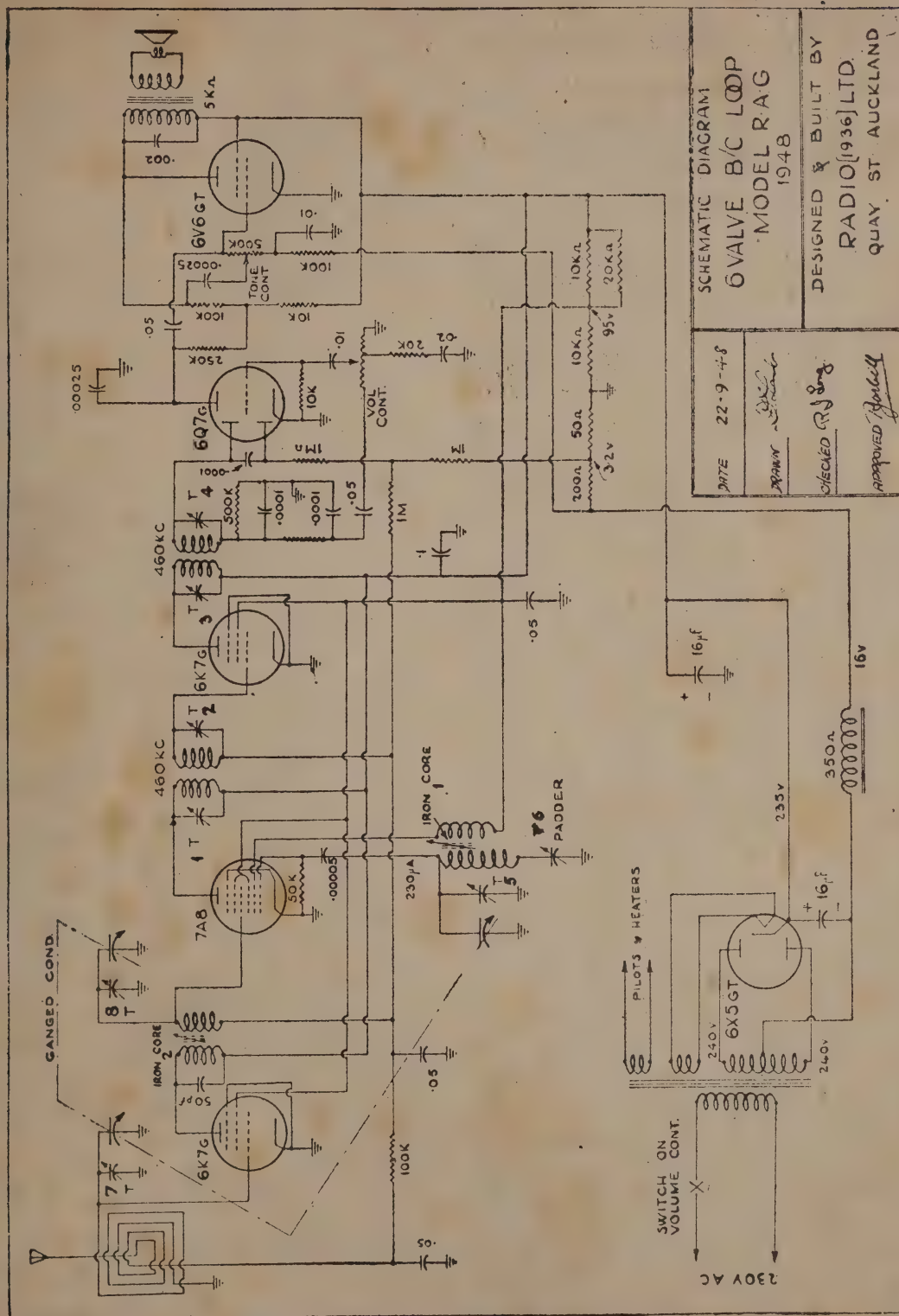
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A NEW HIGH-QUALITY AUDIO AMPLIFIER

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INTRODUCTION

It is some time since we featured a high-quality audio amplifier in these pages, so that it can be taken for granted that readers have by now digested the ideas presented in previous amplifier articles, and will be ready for some more. The object of the present design is to give details of an easily-constructed high-quality amplifier, which is not costly to build, as such things go, and yet will give results comparable with what can be expected from the most expensive of amplifiers.

The principle on which we have worked in designing this amplifier is one which has been advocated by Hilliard, in America—the same designer who has introduced the inter-modulation method of amplifier testing, and who has made many important contributions to fidelity amplifier technique.

According to him, and also to other workers in the field, the best results can be obtained by the use of triodes with negative feedback in the power amplifier stage. Triodes without feedback, it has been found, can not be made to give less than 2 to 2½ per cent. total harmonic distortion, and recent work has shown that an amplifier of this sort shows up quite poorly in scientifically controlled listening tests, compared with either tetrodes or pentodes, in which the distortion is reduced to a very small figure by means of negative feedback. But it has also been shown that a triode amplifier with feedback can give even better results than can tetrodes or pentodes; even more important, these results are obtained with a smaller degree of negative feedback than when tetrodes are used, so that an important factor in favour of triodes is that they make an amplifier of a given small total distortion easier to design and build.

Perhaps the best-known recently designed amplifier of this sort is that described in the "Wireless World" by Williamson. We have referred to this circuit before in these pages. An exceedingly high-quality output transformer is called for if it is to be successfully constructed, but there is no doubt that the results obtained from it are outstandingly good. In this amplifier, a very high degree of negative feedback is used, and it is claimed that distortion is reduced to the proportions of 0.1 per cent. total. Now, the circuit we are about to describe makes no pretence to as little distortion as this. This should be understood from the outset. We have always attempted to "sell" our own circuits on their merits, and it is idle to pretend that any amplifier which does not use the best possible output transformer can out-perform one which does, negative feedback or not! What we do contend, for this circuit, is that its performance will be found very much better than that of the average amplifier described in popular literature, and that, short of the Williamson and similar circuits (which have already appeared in this journal), it will be difficult to better, particularly on a price-for-performance basis. There are very few of us who can

stringent requirements, and in one way or another we all have to put up with something short of the best, particularly in the way of loudspeakers and gramophone pick-ups. In amplifiers, however, it is possible to attain characteristics that are very little worse than the very best, and this article, we hope, shows how this can be brought about at very moderate cost.

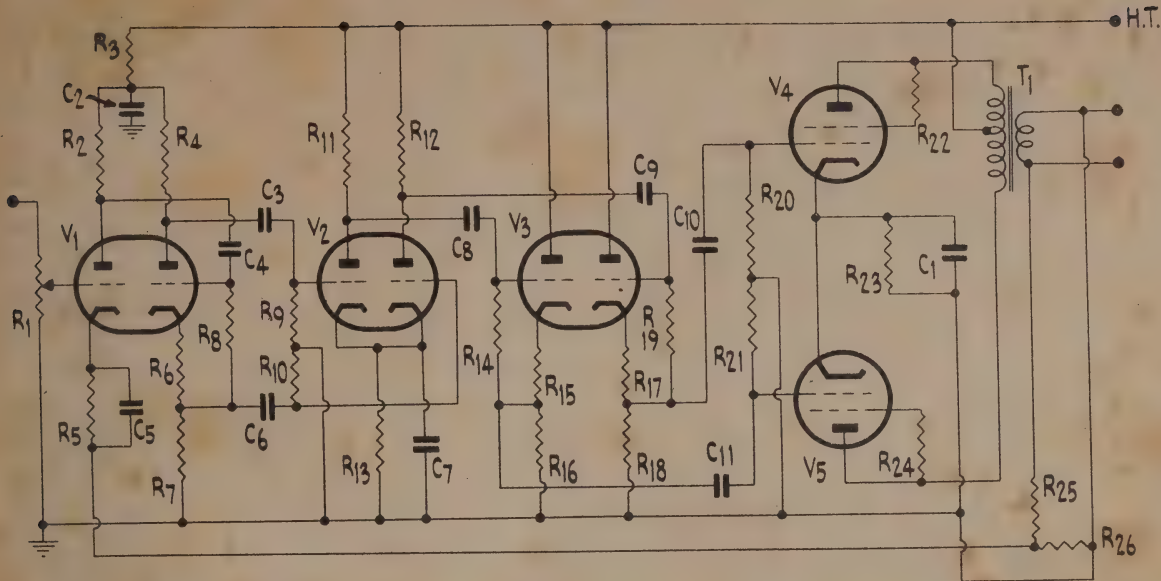
THE CIRCUIT ARRANGEMENT

A few years ago it would have been very difficult to persuade many people to build a circuit like this one, because of the large number of valves used, but since the advent of double-unit tubes, multi-valve circuits can be built at very moderate valve cost. In the present case, six triodes are used, apart from the two in the output stage, but these are all contained in three envelopes, since 6SN7's are used. The first stage is a voltage amplifier. The second, which employs the second unit in the first envelope, is the phase inverter, and uses the well-tried split-load circuit. This gives excellent balance and low distortion, and, although it is not usual to see it anywhere but directly preceding the output stage, there are good reasons for the present arrangement, which will be discussed later.

The next stage is the second voltage amplifier, and uses both halves of a 6SN7 in a push-pull circuit. The third 6SN7 is used as a pair of cathode followers, acting as buffers between the second voltage amplifier stage and the output valves. The circuit as a whole bears distinct affinities with the 20-watt amplifier, using DA30's, that was published in the August, 1947, issue of this journal. The latter, however, used no negative feedback. Here, feedback is taken from the voice-coil winding of the output transformer back to the cathode of the first voltage amplifier. A gain-reduction factor of well over four can be used without instability, and without the necessity for special precautions, so that the distortion will be well under 1 per cent. under any conditions except overload.

THE CIRCUIT IN DETAIL

In designing a feedback amplifier, there are two ways of going about things. The first is to assume that as much feedback as humanly possible will be used. This means that the most important feature is the reduction of phase shift in all parts of the circuit, and that special dodges must be envisaged right from the start, such as making all stages except one with very much wider frequency response than is actually required, and the remaining one with just the required response, and no more. This is a difficult method of approach, but leads finally to something like the Williamson amplifier. It also presupposes that the quality and cost of the output transformer shall be no object, which is seldom true in practice. The other way is to design a "straight" amplifier, without feedback, with as little inherent distortion as possible, and then to apply only enough afford to build equipment according to the most



feedback to bring the distortion down to a tolerable level. This method is much simpler to carry out. One is not tied down to using any particular output transformer, though clearly this component must be as good as can be afforded, and also, no possible harm can accrue if a better one is finally used than was originally intended.

There are some who maintain that the second method is the only correct one; all costs, and all distortion specifications can be met by this method, it is argued, simply by deciding, in any one instance, just what constitutes a "tolerable" distortion level. In the case of the highest possible quality, regardless of cost, the two methods probably boil down to the same thing in the long run, but there is a world of difference in between this, and whatever can be regarded as the minimum acceptable distortion, when the two methods are used. In the case of the first, it is difficult to design for anything short of the best, so that little room exists for compromise performances that will be much better than average, yet not as good as the best. With the latter method, such compromises fit easily into the design.

A further advantage of the second method is that some designers seem to forget that negative feedback is NOT to be regarded as a palliative for poor initial design work. On purely technical grounds, it is better practice to reach a given performance (from the percentage distortion angle) with a small amount of feedback than with a large one. It is quite possible to have a very bad amplifier with lots of feedback, and this does not seem to be generally realized. For example, in designing a complete amplifier, it is easy to take too little account of distortion arising in the voltage amplifier stages, and, although poor design here can be compensated to some extent by the use of feedback, the latter is not an excuse, but merely an expensive remedy for a situation which should never occur in any event.

The burden of the last three paragraphs is, then, that this amplifier is still a good one **EVEN WITH THE FEEDBACK DISCONNECTED**. Those, therefore, who do not care to incorporate the feed-

COMPONENT LIST

- V₁, V₂, V₃, 6SN7.
- V₄, V₅, EL37.
- R₁₃, 500k. pot.
- R₂, R₁₁, R₁₂, R₂₀, R₂₁, 100k.
- R₃, R₄, R₇, R₁₆, R₁₈, 50k.
- R₅, R₁₅, R₁₇, 1000 ohms.
- R₆, 2k.
- R₈, R₉, R₁₀, 250k.
- R₁₃, 1500 ohms.
- R₁₄, R₁₉, 1 meg.
- R₂₂, R₂₄, R₂₆, 50 ohms.
- R₂₃, 250 ohms 10 watts.
- R₂₅, see text.
- C₁, C₃, C₇, 50 μ f. 50v. electro.
- C₂, 16 μ f. 450v. electro.
- C₃, C₆, 0.1 μ f. 600v.
- C₄, C₈, C₉, 0.05 μ f. 600v.
- C₁₀, C₁₁, 0.25 μ f. 600v.
- T₁, output transformer, 6,600 ohms to V.C.

back can do so in the knowledge that good results, both in response and in lack of distortion, will be obtained.

It will be noticed that the three last stages in the amplifier are push-pull ones. Moreover, one of these is a cathode follower stage, and produces no phase reversal of the signal. Thus, it should be possible to group these three stages together as far as H.T. feed is concerned, without any decoupling between them. Normally, only two stages should be so grouped, but, theoretically, push-pull stages, if properly balanced, require no decoupling anyway, and in practice it was found that the theory worked out well. The first two stages—namely, the first voltage amplifier and the phase inverter, are grouped together and decoupled by a 50k. resistor and 16 μ f. condenser. It is best to do the grouping in this way because a decoupling network causes a voltage drop also, and the early stages can do with a low effective H.T. supply voltage much more readily than can the later

ones. This is because the latter have to supply a far greater undistorted voltage output to swing the succeeding grids, and the maximum undistorted voltage output is roughly proportional to the H.T. voltage.

A further point of interest about the design of the voltage amplifier stages is the way in which these are biased differently, in spite of the fact that the same valves are employed in each stage, and similar plate load resistors, too. The bias resistor for the first stage is 1000 ohms, while that of the push-pull second amplifier stage is 1400. Thus, allowing for the fact that the second stage has a common bias resistor for the two halves of the tube, the sections can be regarded as having a bias resistance of 2800 ohms each. The difference is rather great not to have some logical explanation, and has been made purposely for the following reasons. In the first place, the first stage has a lower H.T. supply voltage than the second, and can therefore expect to require a somewhat smaller bias voltage. In resistance-coupled amplifiers, however, this requirement is largely swamped by the fact that self-biasing is to a great extent self-compensating with regard to H.T. voltage changes. Indeed, the difference is much greater than can be accounted for by the difference in the H.T. supply voltages. The scheme is to reduce the bias on the earlier stages, because this stage is handling only a very small signal voltage. For full output, this valve has to handle only an output of $2\frac{1}{2}$ volts peak, at the outside, whereas the second stage has to give an output of 30v. peak, in order to swing the grids of the output stage. It is thus possible to reduce the bias on the first stage and take advantage of the fact that the straightest part of the valve characteristic is the piece just below zero bias. For this reason, where a valve has to handle only a very minute input signal between grid and cathode (0.17v. in this case), it is good practice to under-bias it, and take advantage of the reduction of distortion that ensues. On the other hand, where the largest possible output voltage is wanted (and this is the case with the second stage in this amplifier), it is necessary to bias the valve in the middle of the "straight" portion of the characteristic, giving higher bias voltage and a higher cathode resistor.

There is nothing unusual about the cathode follower or phase inverter circuits, both of them following normal practice for such things. Some, however, will question the necessity, or even the wisdom, of using a stage of amplification after the phase inverter. This particular circuit has been used with much success for a number of years now, but it is rather seldom found anywhere but immediately preceding the power stage. We have used it in this way ourselves, exciting the grids of push-pulls 6A3's. It has one disadvantage, however, and that is that such an arrangement prevents us from having a push-pull voltage amplifier, since all the amplification must then be done before the phase inverter. Now, at least one push-pull voltage amplifier stage is a good thing. Ideally, in fact, it would be best to have all voltage amplifiers in push-pull, and some specially good amplifiers use this. However, here as elsewhere, it is necessary to compromise, unless we wish to acquire further difficulties, and we have decided to use one p.-p. voltage stage. Now, a further disadvantage of the split-load phase inverter, according to some authorities, is that, since its cathode is many volts positive with respect to earth and therefore with respect also to the heater, this type of stage is liable to

generate more hum than other phase inverters which have no cathodes "up in the air." Consequently, Langford Smith, in the "Radiotron Designers' Handbook," recommends that it be used with, at most, a **low-gain** amplifier stage between it and the output grids. In so doing, the signal is kept at a much higher level than the hum voltage that may be generated in the valve. Tests on the finished amplifier showed that the hum level was very low. It was measured across the voice-coil winding of the output transformer, and found to be 60 db. below full output, this being taken at 12 watts, a conservative figure. We have adhered to the recommendation of the "Designers' Handbook," since the gain of the following stage is only 14 times.

PURPOSE OF THE PUSH-PULL CATHODE FOLLOWERS

The idea behind the use of the cathode followers was outlined in an article published by us some time ago (August, 1947) describing an amplifier which used DA30's in the output stage. There, the cathode followers were a pair of 6V6's, triode connected, and were a very important feature of the design, since without them, it would not have been possible to use resistance coupling to obtain the unusually high signal voltage required by the DA30's. Here, though, these considerations do not apply. The cathode followers have been used because of incidental advantages connected with the frequency response and the distortion in the voltage amplifier preceding them.

In reviewing the difficulties inherent in the design of resistance-coupled amplifiers, one finds that a large amount of nuisance-value attaches to the grid resistor of the stage following each resistance-loaded valve. In the present case, we have to provide grid leaks for the EL37's. It is always preferable, from the point of view of the output stage itself, to have a low value of grid leak. In fact, most valves used in output stages have an upper limit to the allowable grid resistance. This is because of the possibility that a certain small grid current might flow, due to contact potential, and, in so doing, go a long way to neutralizing the value of the self-biasing arrangement, or causing excessive bias in fixed bias circuits. In any case, it is good practice to use a low value of grid leak with high-Gm. output valves. Unfortunately, doing so has an adverse effect on the preceding resistance-coupled stage, since it lowers the effective A.C. plate load resistance, thereby lowering the maximum undistorted output voltage at the same time. Looked at in another way, the low grid leak increases the distortion arising in the preceding valve, for a given output voltage, which is the driving voltage of the power stage. From the viewpoint of the voltage amplifier, then, the best sort of grid leak is the highest possible, but the power stage says "No!" to anything over 100,000 ohms, in some cases. Ordinarily, the result is one of our oft-quoted compromises, where the grid leak is made as high as possible with due regard to the output tubes' requirements. The cathode follower, however, provides a complete answer, without any compromise at all—a thing that is not always possible. Its very low output impedance makes it possible to use as low a grid leak as we please in the output stage without any sensible increase in distortion. At the same time it provides an input impedance that can be reckoned at several megohms, thereby allowing the voltage

(Continued on Page 26.)

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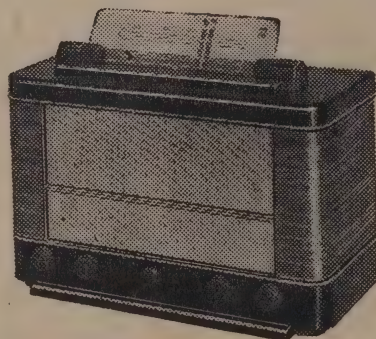
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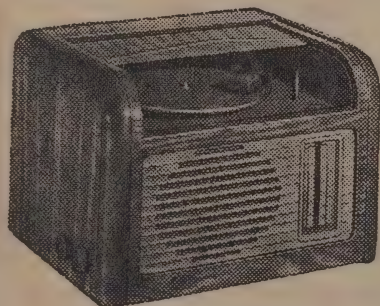
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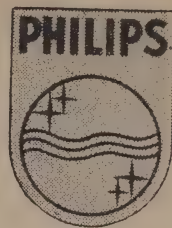
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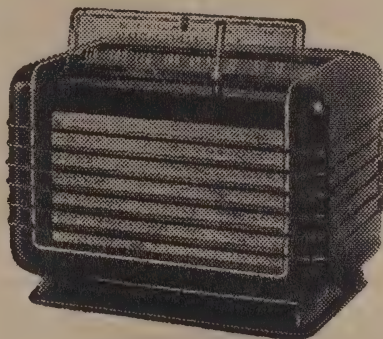
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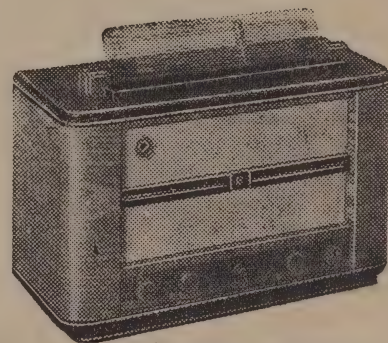
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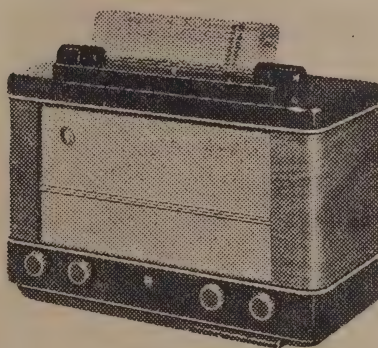
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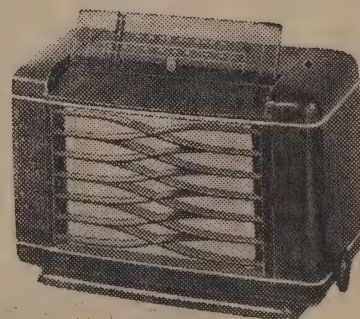
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amplifier to produce a much higher undistorted output voltage, or, which is the same thing, to give less distortion at a given voltage output. In fact, there is some justification for saying that the best possible arrangement would be to have cathode follower buffers between each pair of amplifier valves in any amplifier!

This, then, is the main advantage of the cathode follower buffer stage. And when a single valve and a few resistors are the only price we have to pay for a noticeable advantage of this kind, then there is no reason against using it, except in the cheaper types of equipment.

There are still some advantages that we realize because of the cathode followers, or, rather more directly, because of the low grid leaks used for the EL37's. The main one is that Miller effect arising in these valves has a smaller effect on the high-frequency response than it would otherwise have. The input capacity of any power triode is much greater than the simple grid-cathode capacity of the valve. This is increased many times by the Miller effect, which is caused by feedback through the plate-to-grid capacity and which brings the total up to as much as 60 $\mu\text{f.}$, or even more, depending on the tube type. This amount of capacity, when shunted, as it is, across a high resistance in the shape of the grid leak, can and does produce considerable loss of the

extreme high frequencies, and if it is allowed to appear unchecked in, say, three triode stages, it can render it impossible to give the amplifier a flat response up to even 10,000 c/sec. The use of a low-resistance grid leak does not remove the Miller effect, or its large input capacity, but it does reduce very greatly the effect of it on the frequency response. Incidentally, it is a good rule, in amplifiers which use triodes throughout, to keep the grid leaks all low in value, in order to preserve the extreme highs, if these are wanted.

In the case of the cathode followers, their own input capacity is very low, as the negative feedback has the effect of almost eliminating the Miller capacity. It is thus permissible to use a much higher grid leak in them than in other stages. Their frequency response, by themselves, is flat well into the radio frequency region, so that they can be disregarded as a source of high-note loss.

CONSTRUCTION, Etc.

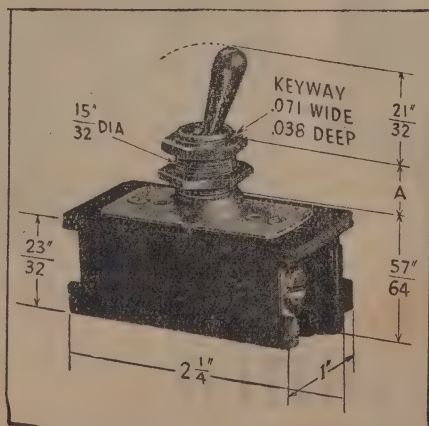
The construction of this amplifier can follow conventional lines, and will be easiest if the valve layout follows the circuit diagram. Only one precaution needs to be taken, and that is to see that the long feedback lead from the secondary of the output transformer does not approach the input potentiometer, R₁, too closely. Luckily, the audio frequency voltage

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on the feedback lead is not very high, so that it will not be difficult to prevent capacitive pick-up by the input grid circuit, especially if the feedback lead is shielded. The latter is quite in order, since the impedance level is only 50 ohms, and the capacity to earth of the shielded lead will have no observable effect on the performance of the amplifier. The cathode resistor of the first section of V_1 should be mounted close to the socket, as usual, with the end that is to be attached to the feedback line anchored by means of an insulated solder lug.

VALUES FOR R_{25}

In any amplifier in which feedback is taken from the voice-coil winding of the output transformer, the amount of the feedback is adjusted as a rule by a voltage divider connected across the voice-coil winding, as here. Unfortunately, the signal voltage to be found at the voice-coil depends, among other things, on the voice-coil impedance of the loudspeaker used. Thus, the amplifier can not be completely specified unless the voice-coil impedance is known. Different builders will want to use different speakers, so that we give below a table showing the values of R_{25} which will give a gain reduction factor of 4 times, R_{26} remaining fixed at 50 ohms.

V.C. Imp. of Speaker.	Value of R_{25}
2.0 ohms	700 ohms
2.5 ohms	780 ohms
3.0 ohms	850 ohms
4.0 ohms	1000 ohms
5.0 ohms	1100 ohms
6.0 ohms	1200 ohms
7.0 ohms	1300 ohms
8.0 ohms	1400 ohms
9.0 ohms	1500 ohms
10.0 ohms	1600 ohms
12.0 ohms	1800 ohms
15.0 ohms	2000 ohms
25.0 ohms	2100 ohms

POWER SUPPLY

The power supply can have any output voltage from 320 to 400, the only differences in performance being those of H.T. current drain and power output. With the former voltage, the power output will be just over 10 watts, and the total drain will be 125ma. With the higher voltage, the current drain will increase to 160 ma., and the power output will go up to 17½ watts. Thus, unless there is a special reason for wanting the extra 7 watts or so, it will be much cheaper to use a 320-volt power supply, which will enable a 125 ma. transformer to do the job. A two-section filter should be used, to keep hum to a minimum. If condenser input is used, and there is no reason why it should not, a voltage of 350-a-side will be ample. If a 385v. transformer is available, and it is desired to make use of it, it would be better to use a choke input filter. However, if the rather better filtering of a condenser input filter is desired, there would be no harm in dropping the extra voltage by means of a heavy-duty wire-wound resistor. This will necessitate the use of an extra filter condenser, unless the resistor is placed in series with the choke, between the existing electrolytics.

CHASSIS LAY-OUT

A suitable chassis lay-out will be given in next month's issue of "Radio and Electronics."

This, it will be noticed, has what appears to be a lot of waste space in the front centre and some extra holes for valves. These have been put there for a purpose, since, in next month's issue, we intend to publish photographs of the built-up amplifier, together with a high-fidelity tuner, push-button operated, built into the same chassis. The extra holes are for the valves and push-button unit of the tuner. The idea of this is that so many constructors build an amplifier, mainly for gramophone use, and then find that they want a tuner, preferably with good bandwidth for high-quality local-station reception. This has to be put on a separate chassis, after which it is found that an "ordinary" tuner for distant broadcast and/or short-wave reception is wanted as well. The constructor then finishes up with a complete outfit built on at least three chassis, and probably with two separate tuning dials, and finds that it is not possible to put the whole lot into a cabinet which has any pretensions to looks, much to the annoyance of his wife or family, who want looks before performance!

The idea of building in the high-fidelity tuner and using push-buttons for tuning it, is one way out of the difficulty. If this is done, there is no dial, as such, so that the complete outfit has only the dial of the "ordinary" tuner. Since this will almost certainly have A.V.C., the latter need have only the tuning knob, with the result that it becomes possible, by a little judicious wangling, to mount the two chassis so that a pleasing arrangement of the dial, control knobs, and push-buttons can be obtained. It is then possible to have a good-looking cabinet made to house the complete system.

It should be mentioned that the push-button unit is used not only for selecting the stations when the high-fidelity tuner is in use, but also to provide the necessary switching from gram. to either tuner.

The article next month will show how all this can be done, and will illustrate in detail the construction of this amplifier circuit in conjunction with the wide-band tuner. This will use a modified version of the scheme, published a few months back, in which the audio bandwidth is obtained by the use of a high intermediate frequency—namely 2.0 mc/sec.

In the meantime, it was thought advisable to publish the amplifier circuit separately, to cater for those who are not interested in the combined gram.-cum-local-radio unit.

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AUDIO EQUIPMENT AND DESIGN:

A New Corner Speaker Design, Parts 1 and 2. Part 1: Design for high-quality sound reproduction. Enclosures designed to accommodate TV tube, but with modifications this feature could be omitted. Design for two cones, high and low frequency. Part 2: Further details of construction. Measured response curves illustrated.

—Audio Engineering (U.S.A.), Jan., 1949, p. 14.

—Audio Engineering (U.S.A.), Feb., 1949, p. 13.

High-power Triode Amplifier. Circuit and construction of an amplifier designed for series of measurements of human hearing, loudspeaker performance, and recording fidelity. Required were high gain, high power, high stability, wide frequency range, and low noise content. Arrangement: p.p. 6J5 input, p.p. 6J5 driving, p.p. 211 type valves, resistance coupled throughout. Power supply is 600 volts from 5R4GY rectifier valves in Bridge circuit.

—Audio Engineering (U.S.A.), Feb., 1949, p. 9.

Flexible Dual Control System. Description of a system using R.C. networks to provide continuously variable boost and cut for both treble and bass, without recourse to feedback. Designed to operate with 800 c/s. as median point. Curves show characteristics of system.

—Audio Engineering (U.S.A.), Feb., 1949, p. 10.

Full Range Loudness Control. Details of construction of loudness control designed to vary frequency response simultaneously with loudness level so that signal matches sensitivity of the ear to various frequencies at different levels of loudness. Range of resistors mounted on wafer switch. Values of resistors specified, also of capacitors used in R.C. bank. Response curves for five of the steps are reproduced.

—Audio Engineering (U.S.A.), Feb., 1949, p. 24.

Audio Design Notes. Chart of magnetic tape, or wire, speed plotted against recorded wavelength.

—Audio Engineering (U.S.A.), Feb., 1949, p. 34.

Latest in High-fidelity Amplifiers. Circuit and construction of a two-unit, 10-watt amplifier using valve type 6AS7 (dual-triode) in p.p. output. Designed for 12AU7 (also dual-triode) valve in preceding p.p. transformer-coupled driving stage. Transformer coupling is employed between all stages. Power supply built in a separate unit. Claimed for 6AS7 are features which make it a particularly suitable valve for hum-free performance.

—Radio News (U.S.A.), Feb., 1949, p. 42.

Equalizer for Phono Amplifier. Circuit and details of a simple R.C. filter consisting of two resistors and two condensers which is intended to eliminate record scratch. Series of curves explains action of a tone control and effect of equalizer.

—Radio News (U.S.A.), Feb., 1949, p. 62.

An Unusual Audio Amplifier. Description of an amplifier in which either 6L6 beam-power tetrodes or 6B4 triodes may be used with similar resulting characteristics. For amplifier are claimed low harmonic and intermodulation distortion and wide frequency response. Comprises four stages: One section of 6SN7 valve as voltage amplifier, other section as split-phase inverter, third stage consists of two 6SS7 valves as p.p. drivers, final stage as already indicated. Full details of construction, feedback system, and adjustments.

—Radio News (Rad. El. Eng. Ed. U.S.A.), Mar., 1949, p. 8.

Variable Reluctance Preamp Equalization. First part of article. Explains necessity for use of pre-amplifier equalizer when variable reluctance type of pick-up is used. Circuit of a commercially manufactured unit which provides compromise between record noise and high-frequency response, and low-frequency response and "rumbles" due to imperfections or maladjustments during recording.

—Radio News (U.S.A.), Jan., 1949, p. 26.

ANTENNAE AND TRANSMISSION LINES:

Reducing Standing Waves. Chart showing degree of attenuation to give reduction of standing waves when bilaterally matched attenuator is placed between load and generator.

—Electronics (U.S.A.), January, 1949, p. 124.

Compact Antenna Coupling Device. Description of commercially manufactured antenna (transmitting) coupling unit consisting of continuously varying inductance. Antenna becomes part of power-amplifier tank circuit and impedance match between transmitter and antenna is obtained by movement of two sliding contacts. Illustration suggests adaptation by amateurs of surplus T1083 H.F. coils, which already have one sliding contact.

—Radio News (Rad. El. Eng. Ed. U.S.A.), Mar., 1949, p. 7.

A Local/DX Antenna for the 7 mc. Band. Details of an omnidirectional antenna with controllable vertical collectivity. For high-angle radiation, antenna functions as a half-wave doublet with link coupling to transmitter. For low-angle radiation, antenna operates as an inverted "ground plane vertical."

—Radio News (U.S.A.), March, 1949, p. 86.

Transmission Line Impedance Measurement. Balanced lines at 100-1000 mc/s. Detailed description of evolution of technique for satisfactory measurement of impedance when balanced-feeder systems employed. Method adopted was measurement of standing-wave patterns.

—Wireless Engineer (Eng.), March, 1949, p. 78.

Spiral-phase Fields. Article explains method of originating spiral-phase field by arrangement of four vertical aerials. Description of Archimedes spirals. Three main applications of spiral-phase fields are outlined. These are: Radar range, light-house or talking beacon, and as a substitute for narrow beam arrays.—Wireless Engineer (Eng.), March, 1949, p. 96.

CIRCUITS AND CIRCUIT ELEMENTS:

High-Q Variable Reactance. Use of cathode-coupled dual-triode valve to give high Q and wide range of reactance variation combined with simplicity. Circuit has been applied to frequency modulated oscillators at audio and radio frequencies, and to variable frequency R.C. filters. Description of two frequency modulated oscillators, one using basic circuit and one the circuit described, both operating at radio frequencies. In this circuit, one section of valve functions as cathode-follower amplifier; other section as cathode-follower for variable load resistance of first section.

—Electronics (U.S.A.), January, 1949, p. 118.

Fractional Frequency Division by Feedback. Usual limitation of frequency division circuits is that operation confined to integral step-down ratios. Application of feedback networks to multivibrator chain makes available prime ratios and permits use of non-integral rational numbers. Basic circuits and operation described.—Electronics (U.S.A.), January, 1949, p. 171.

Electronic Circuitry. (1) The "Bootstrap" circuit for producing saw-tooth waves. For use in time bases for pulse examination, and photographing recording of high-speed transients. Fundamental and modified circuits drawn, operation discussed. (2) Simple thyatron motor speed control. Circuit and operation.—Wireless World (Eng.), March, 1949, p. 92.

A Linear Resistance-charged Gas Relay Time Base. Details of a circuit which obviates necessity for special transformer with extra insulation and screening as in conventional gas relay time-base design. In this circuit all heaters and cathode and grid of gas relay are near ground potential. Requires only two valves. Circuit not recommended for large tubes or where high precision required.

—Electronic Engineering (Eng.), March, 1949, p. 101.

Two New Multivibrators. Circuits of a modified Eccles-Jordan trigger circuit for free-running multivibrator. Second circuit of free-running multivibrator provides for alternate switching of grid of first valve from zero to approximately cut-off, whilst grid of second valve is always positive. First valve conducts periodically and second always draws grid current. Anode of first valve is below H.T. potential. Modification provides for self-bias on first valve to control repetition frequency.

—Electronic Engineering (Eng.), March, 1949, p. 102.

FREQUENCY MODULATION:

F.M. Receiver Design Problems. Outline of problems arising during design of F.M. as compared with A.M. receivers. Techniques employed by designers and manufacturers. Discussion covers limiter and balanced discriminator detector, synchronized oscillator detector, and elimination of regeneration in I.F. and R.F. amplifiers.

—Electronics (U.S.A.), January, 1949, p. 104.

F.M. Tuner Design. Article outlines major requirements of good tuner design and discusses features of seven types of tuning circuits adopted by respective U.S. manufacturers.

—Service (U.S.A.), January, 1949, p. 10.

INDUSTRIAL APPLICATIONS:

R.F. Brazing of Radio Components. An example of use of induction heating in assembly of radio equipment. In this instance, dummy F.M. antenna consisting of copper spinning of special design.—Electronics (U.S.A.), Jan., 1949, p. 111.

MATHEMATICS:

Thevenin's Theorem. Explanation of application to simple network calculations.

—Wireless World (Eng.), March, 1949, p. 109.

MEASUREMENTS AND TEST GEAR:

Distortion and Noise Meter for testing Broadcast Equipment. Circuit and details of construction of device for checking noise and distortion of broadcasting and other audio equipment such as public-address systems. Method of calibration. Meter covers audio range from 50 c/s. to 50,000 c/s. and reads noise levels down to minus 60db. directly. Null T-bridge filter circuit incorporated to give high selectivity.

—Electronics (U.S.A.), January, 1949, p. 86.

Converted Home Receiver Ideal for Signal Tracer. With slight modification and the addition of a valve-type (6SQ7) R.F. probe, an A.C. receiver may be used as a signal tracer without disabling it as a home receiver. Details of probe circuit and assembly, and method of adapting receiver for use as above. Instructions for using signal tracer.

—Radio News (U.S.A.), February, 1949, p. 60.

An Electronic Volt-ohmmeter. Employs cathode-coupled triodes (type 38 valve, triode connected) with large amount of feedback for stability. Has input impedance of 23 megohms on D.C., 2.2 megohms on low-range A.C., and 18 megohms on high-range A.C. External probe used for R.F. voltage readings. Provision for wide range of readings.

—Radio News (U.S.A.), March, 1949, p. 59.

Wide-range Amplifier Increases Sensitivity of V.T. Voltmeter. Voltage amplifier to precede V.T. voltmeter giving increased sensitivity. Circuit of unit which has overall gain of 85 and which is said to be flat within 1½ db. from 60 c/s. to 2 mc. Uses 6AC7 and 6AG7 valves.

—Radio News (U.S.A.), March, 1949, p. 78.
Improved Accuracy with a Q-meter by the Use of Auxiliary Components. Using reactance-variation method of measurement of Q, proposal is to increase voltage input to unit in known ratios and ascertain extent to which circuit must be detuned to maintain constant voltage in it. Thermocouple and reflecting galvanometer are necessary accessories. Details of operations in taking measurements.

—Electronic Engineering (Eng.), March, 1949, p. 91.
Electronic Measurement and Control of Heat. Part 3. Electronics and welding.

—Electronic Engineering (Eng.), March, 1949, p. 94.
RECEPTION AND RECEIVERS:

Midget A.C. Mains Receiver. Circuit and construction of two-valve (EF50) receiver comprising grid-leak detector and resistance-coupled amplifier, using surplus parts.

—Wireless World (Eng.), March, 1949, p. 94.
A Compact 10-meter Converter. Simple converter using 6J5 type triode valve as oscillator and similar valve as mixer. Circuit and details of construction.

—Radio News (U.S.A.), February, 1949, p. 45.
Reflex Amplified Considerations in Receiver Design. Reflex circuit employed in three-valve receiver. Valve types are: 12SA7 det. osc., 12SF7 I.F., and 70L7 second detector and output. A.V.C. not provided. Details for overcoming inherent disadvantageous features of reflex circuits.

—Radio News (U.S.A.), February, 1949, p. 46.
Build Your Own Communications Receiver. Concluding article with directions for assembly of previously described units in

single panel-mounted unit.

—Radio News (U.S.A.), February, 1949, p. 50.
A One-tube 2-meter Superhet. Design of a receiver using 12AT7 (dual-triode) valve. One triode section functions as R.F. detector, amplifier, converter, I.F. amplifier, and super-regenerative second detector. Other section as local oscillator. Circuit is a modification of Hazeltine Fremodyne superregenerative circuit. Audio amplifier required as supplementary unit.

—Radio News (U.S.A.), February, 1949, p. 44.

TELEVISION:

Modern Television Receivers. Part II. A description, with circuits, of types of video frequency amplifiers, more particularly those in favour with U.S. manufacturers.

—Radio News (U.S.A.), February, 1949, p. 66.
Modern Television Receivers. Part 12. Reason for D.C. restorers in TV receivers and their operation.

—Radio News (U.S.A.), March, 1949, p. 66.
TRANSMISSION AND TRANSMITTERS:

Pulse Count Modulation. A clear and detailed explanation of the system of pulse count (or code) modulation.

—Wireless World (Eng.), March, 1949, p. 82.

Range of V.H.F. Part 1. Air to ground communication. Discussion of effect of transmitter power upon range of equipment. Curves showing theoretical ranges of communication with aircraft for ground transmitters of different power and height of aerial. Evaluation of results obtained from practical tests.—Wireless World (Eng.), March, 1949, p. 107.

A Novel Break-in V.F.O. Circuit and construction of V.F.O. in which oscillator section is carefully shielded to make break-in operation possible. Uses 6SS7 type valve as oscillator (160 metres), 6AG7 Class A amplifier (untuned), and 6F6 output-frequency doubler. Voltage regulation incorporated. Cathodes of amplifier valves are keyed.

—Radio News (U.S.A.), March, 1949, p. 46.

(Continued on page 48.)

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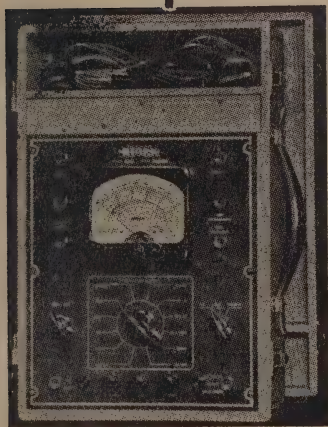
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TUBE DATA: THE C67 DUO-DIODE HIGH-MU TRIODE

APPLICATION

Type 7C6 is a single-ended duodiode high-mu triode having electrical characteristics quite similar to those for Type 75, except for the heater ratings.

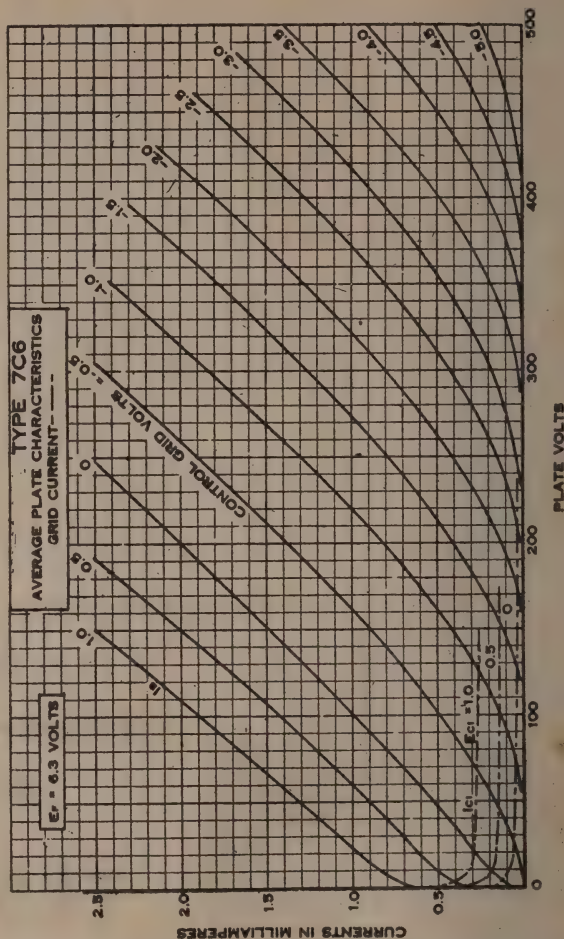
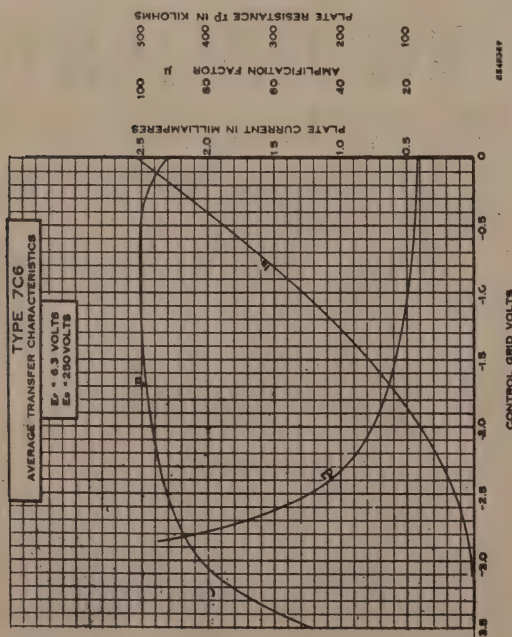
The diodes are substantially the same as those employed in other duodiode high-mu triode types and therefore are suitable for conventional circuit applications. Diode curves are given under Type 7B7.

The triode section should not be employed with fixed bias. A high value of grid resistor is required and the triode operated essentially under zero bias conditions. With a plate supply voltage of 250 volts, the plate load resistor should be approximately 0.25 megohm. For special applications this value may be varied to suit the conditions.

It will be noted from the base diagram that the



Base connections and electrode arrangement of the 7C6



cathode is connected to two contact pins, Numbers 4 and 7. Pin Number 4 is used as a mount support for the cathode; therefore, the potential of Pins 4 and 7 is the same.

The lock-in construction provides compactness, suitable shielding, and the special lock-in feature.

RATINGS

Heater voltage A.C. or D.C. (nominal)	7.0 volts
Heater current (nominal)	0.16 ampere
Maximum plate voltage	300 volts
Maximum diode drop at .8 ma.	10 volts
Maximum diode current per plate (continuous)	1.0 ma.
Maximum heater-cathode voltage	90 volts

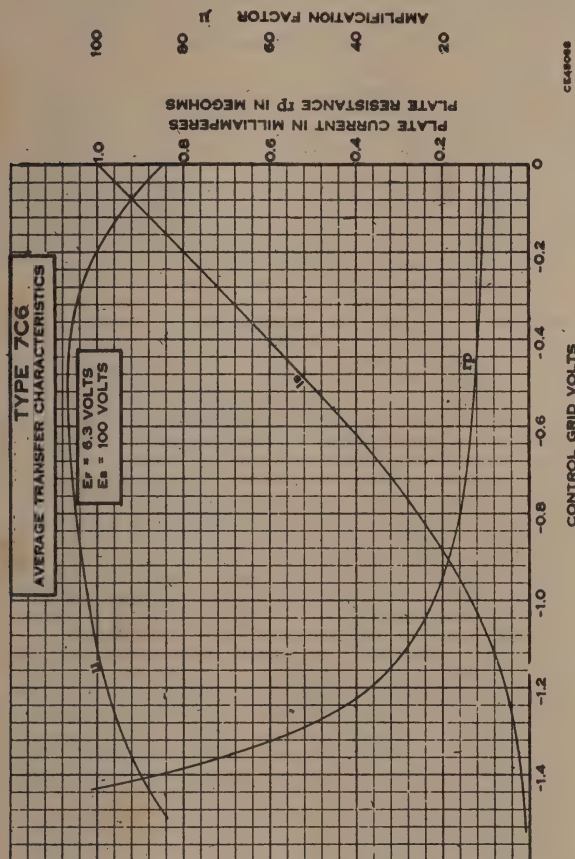
TYPICAL OPERATION

Heater voltage	6.3	6.3 volts
Heater current	0.150	0.150 ampere
Plate voltage	100	250 volts
Grid voltage*	0.0	-1.0 volt
Plate current*	1.0	1.3 ma.
Plate resistance*	0.1	0.1 megohm
Mutual conductance*	850	1000 μ mhos
Amplification factor*	85	100

*These are rating values only and not operating points with coupling resistor. Refer to tabulated data for this information

PHYSICAL SPECIFICATIONS

Base	Lock-in 8 pin
Bulb	T-9
Maximum overall length	2 25/32 in.
Maximum seated height	2 1/4 in.
Mounting position	Any



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A Practical Beginners' Course

PART 32

In our last issue we were discussing the circuit of Fig. 45, which is that of a triode radio frequency amplifier. We had got as far as saying that unfortunately this circuit is not a practical one, because, although it undoubtedly amplifies, it will not do so without bursting into oscillation, which means that it is generating radio energy itself and completely masking the signal we are trying to receive. Before we can make a successful R.F. amplifier, we must find out why this state of affairs comes about.

We said, further, that it is because of invisible components which do not appear on the circuit diagram, and promised to explain this rather startling statement. Inside the valve we have three electrodes, the plate, the grid, and the filament, or cathode. Apart from their special uses which make the valve work as a valve, these parts also act in ways that we do not necessarily want. That is to say, we are not interested, in the ordinary way, in connecting a condenser directly between the grid and plate of the valve, because our circuits do not call for such a connection, but what we must now realize is that we have such a condenser present, whether we like it or not. The condenser we are referring to is simply that which is formed by the closeness of the grid to the plate, which makes the two electrodes act like a very small two-plate condenser. The capacity is quite small—only in the region of 5 to 10 $\mu\text{mf.}$ —and for some purposes it can be regarded as absent. For instance, when we use the valve as an audio amplifier, this capacity is there all right, but it is so small that at audio frequencies it has almost no effect, and we design and construct our circuit as though it did not exist at all. But when we come to radio frequencies, the effect of this capacity is much larger, and its practical effects are so great that it can no longer be ignored.

The same thing goes for the capacity that exists between the grid and the cathode or filament. This is also a very small condenser, and can sometimes be disregarded at low frequencies, in the same way as the grid-plate capacity, but at radio frequencies it also comes into the picture. Very often, as in our one-valve circuits, we do not have to bother about it very much, because its effect is simply to add a very small amount to the capacity of the tuning condenser, but it is still there nevertheless, and when we get to very high radio frequencies, it makes it very difficult to obtain tuned circuits that are at all good unless special dodges are used in the circuits.

The third "invisible" capacity about the valve is the one between the plate and the filament or cathode. In the data given us by the manufacturers of valves, there is always a small section devoted to stating the values of the three **inter-electrode capacities**, as they are called. This is because it is necessary to know their values in a great deal of design work, and because their values sometimes determine the suitability or otherwise of a certain valve type for the particular application.

Here, however, we are more interested in the grid-plate capacity than the others, because it is the existence of the grid-plate capacity which causes the circuit of Fig. 45 to act as an oscillator. It will be

remembered that the special property of any condenser is that it blocks the passage of direct current, but allows A.C. to pass through it. Now, the ease with which alternating currents pass through a condenser depends upon two things: first, the size of the condenser, and, secondly, the frequency A.C. The

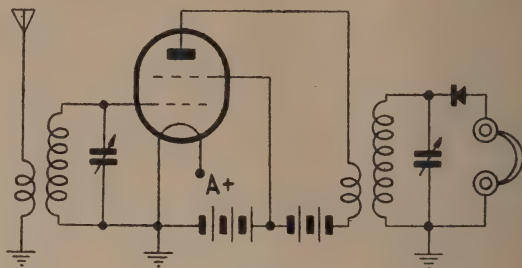


Fig. 46

larger the condenser and the higher the frequency, the more easily the A.C. passes through. Thus, although the size of the grid-plate capacity is so small, the frequency is very high in an R.F. amplifier, so that the R.F. passes quite easily from the plate to the grid. Since the R.F. voltage has been amplified in passing through the valve, and because of other considerations which we cannot go into here, the R.F. applied to the grid of the amplifier valve through the grid-plate capacity causes there to be an **increased** R.F. voltage at the grid. This voltage is further amplified, and some of it is in turn applied to the grid again. This process, whereby voltage is fed back from the plate circuit to the grid circuit of the valve goes on until the valve no longer requires any input signal to keep it going and the valve is generating its own signal, which is the oscillation we have spoken about.

What, then, can be done about it? In the days when the only valves were triodes, this was quite a problem, and was attacked in a number of ways. One obvious one is to try to make a valve with so small a grid-plate capacity that not enough R.F. voltage is fed back to the grid to allow the valve to oscillate on its own account. Another way, and this was the first one to be successfully applied, is to arrange the circuit in such a way that the voltage fed through the grid-plate capacity is exactly cancelled out by another voltage, derived from the circuit, and purposely fed back to the grid also. This process is called **neutralization**, and, while it is no longer used in receivers, where it is difficult to apply, it is still used in transmitters, which often use triodes for amplifying the R.F. generated by an oscillator.

In receivers, the problem has been solved by the development of the screen-grid valve. In this valve, the grid-plate capacity is not entirely eliminated, for this can never be done, but it is reduced to a very small fraction of its value in triodes. Most screen-grid valves have an almost unbelievably small grid-plate capacity, generally less than 0.01 $\mu\text{mf.}$, and this is small enough to allow the valve to work without oscillating, even at very high frequencies indeed.

CIRCUIT FOR A SCREEN-GRID VALVE

In Fig. 46 we have an R.F. amplifier and detector circuit which uses a screen-grid valve such as we have already described. Comparing this with the circuit of Fig. 45, it can be seen that there is really very little difference between the two circuits. In Fig. 46, we have drawn the B battery, which this time is in two parts, the sections being connected in series. The lead from the screen-grid is taken to the tap on the battery. If the screen and its connecting wire were eliminated from the diagram, the circuit would be exactly that of Fig. 45. Thus, we see that the introduction of the screen-grid does not introduce very much complication into our circuit at all. The action of the screen in reducing the grid-plate capacity of the tube is similar to the action of a metal screen placed between the grid and the plate—hence the name. Although it is at a high potential as far as D.C. is concerned, being connected to a tap on the battery, the screen-grid is at earth potential for

signal frequencies, because the battery acts as though it were a large bypass condenser, and prevents any signal voltage from appearing on the screen.

PRACTICAL CIRCUITS

Although it is so simple, the circuit of Fig. 46 is quite a practical one, and it would be possible to build it and make it work successfully. If you have, or can come by an old type of screen-grid valve such as a 32 or a 34, this could be tried with only 45 volts total B battery, and the tapping at 22.5 for the screen. Alternatively, the screen could be connected straight to the 45-volt battery, thereby running it at the same voltage as the plate. These types are low-consumption 2-volt filament valves, and with the low plate and screen voltage of 45, will not need any grid bias voltage at all, so that the circuit can be just as it stands. If we look at the diagram of a 34, we might find it drawn with three grids, making it a pentode, as, in fact, it is, but since the extra grid is connected inside the valve and has no base pin,

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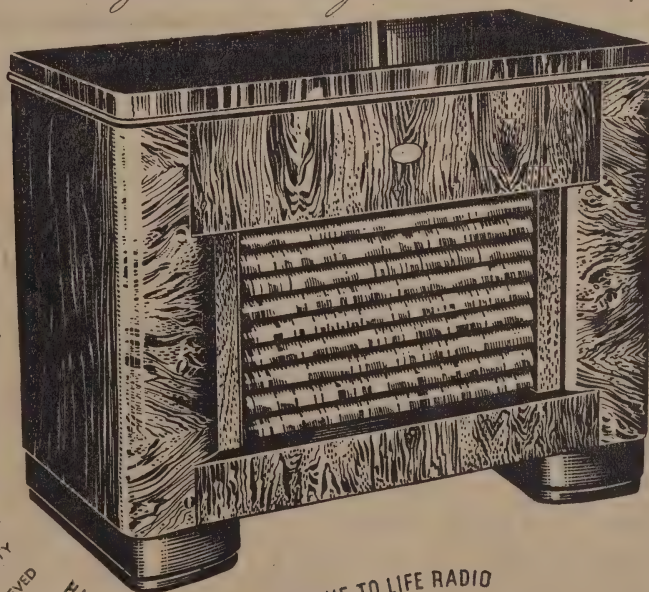
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this makes no difference to the way of hooking up the circuit. In both the 32 and 34, the control grid is connected to the top-cap, while the pin which in a four-pin triode would be the grid, is the connection for the screen-grid.

If it is decided to build this circuit, as an experiment, both coils can be the same, and also both tuning condensers. The primaries can also be the same as each other, and can have 25 to 30 turns on the 3 in. diameter former. The aerial coil can be the tapped coil made for earlier crystal sets, and for which the details will be found some way back in the course. If a special coil has to be made for the detector, the primary can be done the same as on the tapped aerial coil, except that there will be no need for any taps this time. To tune the set in for the first time, the first tuning condenser can be set somewhere near where experience has shown that the crystal detector will tune for the local station, after which tuning, and adjustment of the detector can be done until a signal is heard. Once a sensitive spot on the crystal has been found, we can try tuning for the other local stations. Since the coils and tuning condensers are identical, the stations should be properly tuned in with about similar settings of the two condensers. In any case, when a signal is picked up, it can be brought to its best strength by tuning first the detector condenser, and then the aerial one, both for the loudest results.

This circuit will give the beginner a good idea of the usefulness of amplification at radio frequencies, before the signal is detected. Comparing the results obtained with the circuit of Fig. 46 with those of the crystal set by itself will show that stations

that were just too weak to listen to comfortably, without the R.F. amplifier stage, are brought up to quite listenable volume, and some will even find that stations that previously could not be heard at all are now received quite well. If you have one of our simple one-valve sets built up and add the R.F. amplifier to it, it will be possible to learn quite a lot. It will be found that, although the regenerative set is so sensitive that it can pick up very distant stations, the addition of the R.F. amplifier will have improved the performance considerably, because now, the detector will not have to be set to the most sensitive possible condition to receive even very weak stations. Also, the increase in selectivity, due to having two tuned circuits instead of only one, will be very apparent whether the amplifier is used with the crystal detector or the valve detector. This will be most noticeable when one is trying to tune out a strong local station in order to hear a comparatively weak one, which is received well when the local is off the air, but which is almost blotted out by the latter when it is on.

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2-METRE CONVERTER

(Continued from page 16.)

aerial is coupled loosely to the mixer coil. The trimmer is then peaked up for maximum noise from the receiver, or to give maximum output on a signal that may be picked up on the low-frequency end of the 40m. band.

Finally, all that has to be done is to see that the input tuned circuit hits the spot. To do this, an oscillator on the 144 mc/sec. band will be needed. It can be a "flea-power" one, hitched up for the occasion, and set to frequency by means of the Lecher wires, or it can be the transmitter that is intended to be used with the receiver. This will give a check on the setting of the oscillator circuit, since, even with the aerial circuit de-tuned, there will be enough stray signal in the converter to give an appreciable output. When the signal has been tuned in with the oscillator tuning condenser, the input tuning condenser is adjusted to give maximum signal output. If the line is made as per specifications, it

should tune all right without further ado. If a very strong stray field is getting into the converter, the tuning of the input circuit may not be noticed, so that it is best to ensure that a weak signal is coupled into the converter through the aerial coupling hairpin; this should overlap the end of the line by about three inches, and can be quite closely coupled in, the coupling being adjusted once the converter is finally "on the air."

One final point: The R.F. choke should consist of approximately an inch of winding with 30-gauge wire, on a $\frac{1}{2}$ -watt carbon resistor, used as a former. If it is working properly, the oscillator plate or grid current should not change when the H.T. end is touched with the finger. If it does change, the remedy is to take turns off until the test is satisfactory.

The best sort of aerial to use is clearly one cut specially for the band, and one of the many aerials described in the amateur literature can be chosen. A simple half-wave dipole, or a folded dipole, will be found to give excellent results.

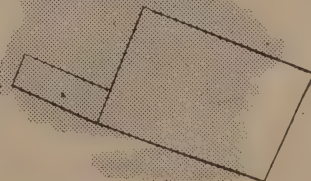
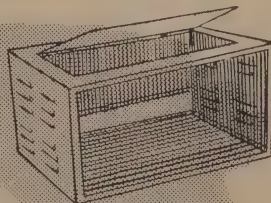
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DESIGN SHEET No. 8

POWER DISSIPATED IN A RESISTANCE

The formulae for the power dissipated in a resistance are extremely simple ones, but are awkward to work out quickly, owing to the presence of the squared term, either I^2 or E^2 , depending on which formula is being used. The formulae are—

$$W = I^2 R \text{ and } W = E^2 / R,$$

where W is the power in watts, I is the current in amperes, and E is the voltage.

The questions that are most often required to be answered by means of these formulae are: "How much current can be passed through the resistor without exceeding its power rating?" and "How many volts can be dropped through the resistor without exceeding the rating?" The ability to work this out quickly, either for the current case, or for the voltage case, is often of great assistance, and can save many faults in experimental gear through originally not inserting a highly enough rated resistor. The present Design Sheet is therefore presented as a rapid means of working out the first of these questions, and others related to it. For example, suppose we have a resistor rated at 1 watt and with a value of 250 ohms. This could be used as the bias resistor for a 6V6, provided that the power dissipated by the plate and screen currents flowing through it is not greater than the 1 watt allowed for it. What we want to know is whether the cathode resistor of the 6V6 is called upon to dissipate more or less than 1 watt, and, if the answer is "more," what wattage rating is required in the resistor that is used instead of the 1-watt article.

To answer these questions, all we have to do is to take a ruler and lay it across the chart so that it joins 250 on the ohms scale with 49.5 on the milliamps scale. We then read off the watts dissipated by noting where the ruler cuts the watts scale. The answer is 0.58 watt, so that it is clear that a 1-watt resistor will do for this application.

SOME OTHER PROBLEMS

Some other quite different problems can be attacked by means of the chart. For example, suppose we wish to measure the power output of a transmitter. We propose to do this by using a number of carbon resistors in series or parallel as the non-inductive load for the transmitter, which has a rated output of 20 watts. Thus, four 5-watt or 10 2-watt resistors will be required. What we want to know is what value of load resistance must we use in order that the R.F. current THROUGH the load resistor will not exceed 1 amp. The reason why we want to know this is that we have a 0-1 amp. thermocouple meter, and we are going to measure the power of the transmitter by using a known load resistance and measuring the current with the thermo-ammeter. This problem can make use of the chart twice, once to find the smallest load resistance that can be used, in order not to pass more than 1 amp. through the meter, and, again, when the reading has been taken, to find out what the actual power output is.

Taking the first part first, we have (a) the power will not be greater than 20 watts, and (b) the greatest allowable current is 1 amp. We therefore lay our ruler across the chart from 10 on the watt scale to 1 on the ampere scale. Unfortunately, we find that the ruler does not intersect the ohms scale

at all. It would appear, then, that the chart cannot cope with this problem, but there is a way out. If we use 2 on the watt scale and 100 ma. on the current scale, thus dividing both the original values by 10, we find that the intersection on the ohms scale is at 200 ohms. If now we divide this by 10, we will have the answer—namely, 20 ohms.

The final step is to make up the 20-ohm resistor, attach the meter in series, and couple the combination into the transmitter as a dummy load. When properly coupled in, so that the rated plate current is drawn by the final amplifier, the load current is read as 0.95 amps. Since 20 ohms is off the scale, we now multiply this by 10, getting 200, and lay the ruler between this and 95 ma. on the current scale. This gives us an answer on the watts scale of 1.8 watts, which, when multiplied by 10, gives the final answer as 18 watts.

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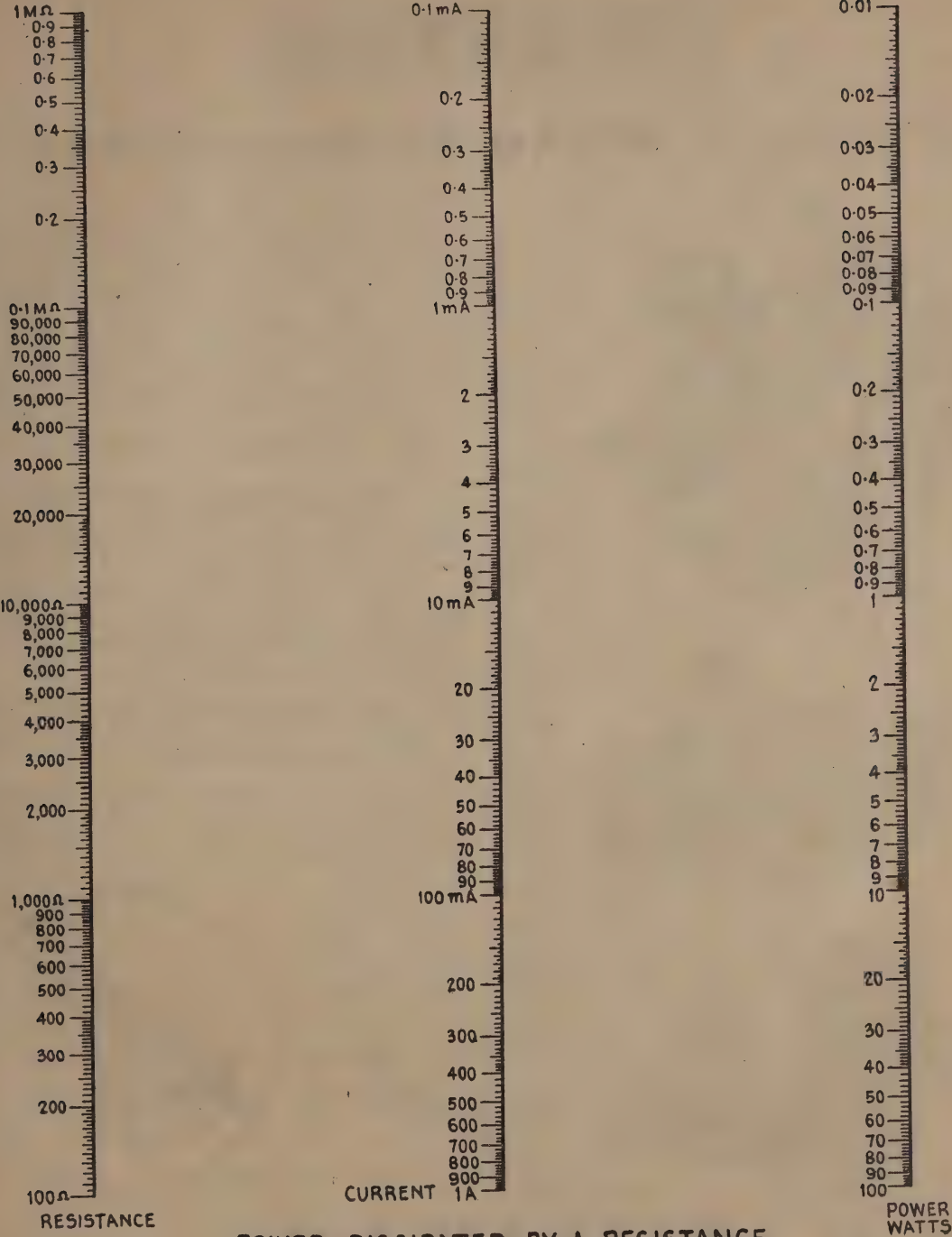
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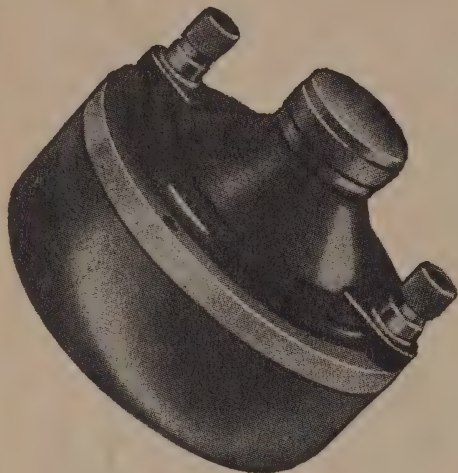
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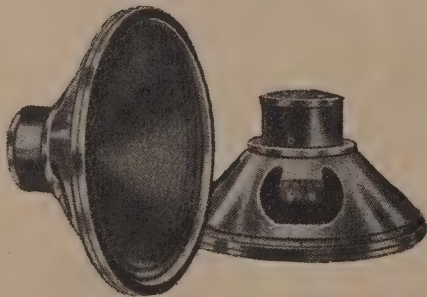


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HIGH-FREQUENCY R.F. CHOKES

(Continued from page 10.)

cycles. This means that at 45 mc. the choke will appear to have no inductance and no capacitance. The impedance at 45 mc. will be quite high and will appear to consist only of pure resistance.

At higher frequencies, the choke will appear to have a very high resistance and some small amount of capacitance. This capacitance may be in the order of a micro-micro-farad. A small amount of capacitance in this order will not affect the operation of the choke.

A review of the above in capsule form shows us that (1) Regular 2.5 mh. R.F. chokes, designed for operation over a wide frequency range, are generally not too efficient on the higher-frequency bands (10 metres and up). (2) For optimum operation, R.F. chokes should be designed for one frequency, especially for the more critical service as parallel chokes. Home-made chokes for low-frequency work would be bulky and difficult to construct, but for high-frequency work single-layer R.F. chokes are easy to construct and have the advantage of being almost perfect chokes electrically.

CONSTRUCTIONAL DETAILS

High-frequency R.F. chokes may be wound on practically any insulating material, such as wood, bakelite, or polystyrene. The exact nature of the insulating material will determine, to some extent, the quality of the completed choke. Generally it is not necessary to go to these materials, as very satisfactory chokes can be wound on ordinary resistors.

WINDING DATA

Complete winding data for four high-frequency chokes:—

10-11-metre choke: No. 30 enamel wire close wound to cover $1\frac{1}{2}$ in. on an old-style 2-watt resistor (5/16 in. diameter).

6-metre choke: 44 turns of No. 30 enamel wire wound on new-style 2-watt resistor (5/16 in. diameter).

2-metre choke: 17 turns of No. 22 enamel wire wound on new-style 2-watt resistor (5/16 in. diameter).

1.25-metre choke: 16 turns of No. 22 enamel wire wound on new-style 1-watt resistor (7/32 in. diameter).

Use only insulated composition type resistors (not wire wound). Use resistors of a high value—one megohm or higher. File a notch on each end to catch the wire and hold it. The wire can be soldered first to one pigtail, the choke wound, then the wire twisted round the other pigtail, the insulation removed, and then finally soldered.

Do not attempt to make any changes in specifications. Use the proper resistors and the right size enamelled wire. A thin layer of coil cement may be placed on the completed chokes if desired.

The 144 and 220 mc. R.F. chokes specified above use heavy enough wire so that they may be employed in filament circuits if the current does not exceed one ampere. The 28 and 50 mc. chokes are to be used only in circuits where the current is in the order of 0.1 amperes, although they might possibly stand twice this current in amateur service. All of the chokes are suitable for use as shunt-feed chokes.

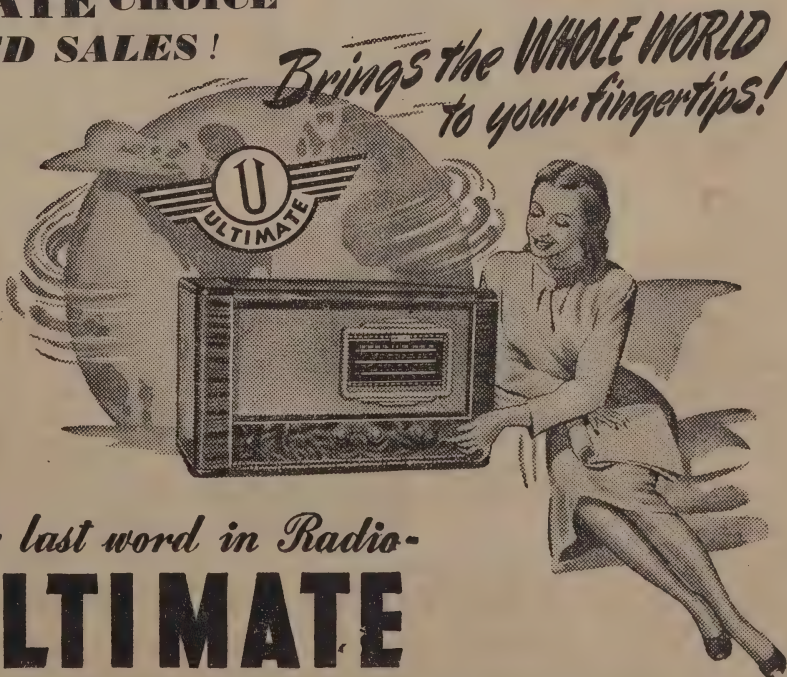
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HUM IN HEATER-CATHODE VALVES

When A.C. valves are used as low-level amplifiers, the hum appearing in the output after adequate H.T. filtering has been applied is often due to the fact that the first valve is heated by A.C. This hum has been called heater-cathode hum, but there are at least two kinds of hum from this source. The first is that which arises through minute leakage currents between the cathode and the heater of the valve. Unless the cathode is above earth potential, this kind of hum cannot occur, so that one sure way of eliminating it is to earth the cathode of the offending stage directly and use fixed bias instead of cathode bias. This is not always effective in removing the hum, because it has no effect on the second type of hum to be described. This is called heater emission hum, and is due to the emission of electrons by the heater, so that some of them are collected by other electrodes—usually the grid. Earthing the cathode can obviously have no effect at all on this sort of hum.

TESTING FOR KIND OF HUM

To test for leakage hum, a battery of a voltage as close as possible to the cathode bias voltage developed by the cathode resistor is connected to the cathode of the valve, the positive to the cathode and the negative to earth. The battery ensures that the bias voltage remains unaltered, but acts as a short-circuit to signal and hum voltages. If, on applying this test, the hum disappears altogether, the hum was due to leakage, and can be cured by earthing the cathode of the valve and using an alternative bias source.

To test for emission hum, first disconnect the coupling from the previous valve, if any, and earth the grid of the valve. If hum disappears, it was due to emission by the heater to the grid. Perhaps the best way of curing emission hum is to place the heater at a fairly high positive potential with respect to the cathode. The effect of this is that the heater is unable to emit electrons that will be collected by the grid, because this is negative with respect to the heater and so repels the electrons instead of attracting them.

Climatic and Durability Tests for Radio Components

AN INDUSTRY SPECIFICATION

A specification describing the general conditions and procedure for durability testing of components for radio and other electronic equipment is published by the Radio Industry Council. The specification, No. RIC/11, is the work of the R.I.C. Technical Specification Committee in consultation with the British Radio Equipment Manufacturers' Association, the Radio Communication and Electronic Engineering Association, and the Radio Component Manufacturers' Federation, and is the first produced by the Committee. It covers approximately the same ground as the Inter-Services Specification No. RC.S/11, but caters for the industry's own requirements as distinct from those of the Services. It has not yet reached the stage of consideration by the British Standards Institution.

The object of the Technical Specification Committee's work is to produce a series of radio components specifications designed to ensure a high standard of reliability and performance for British components during use, transit, and storage. The first basic need is to devise a standard series of tests for components—a yardstick by which they can be measured—and RIC/11 is intended to fulfil that need.

Components will be examined and their properties measured before and after they are subjected to the tests and their performance under test will be laid down in the relevant component specifications. Components will be classified under the headings according to their ability to withstand extremes of temperature and humidity.

Supplementary tests for vibration, salt atmospheric corrosion, and mould growth may also be called for.

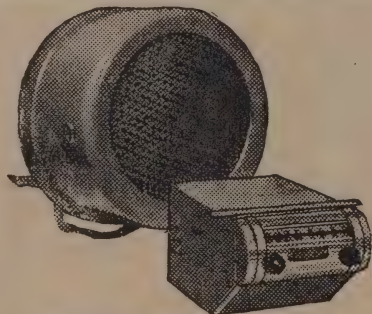
Copies of the specification can be obtained, price one shilling, from the Radio Industry Council, 59 Russell Square, London, W.C.1.

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QUESTIONS and ANSWERS

AN UNUSUAL PRE-AMPLIFIER

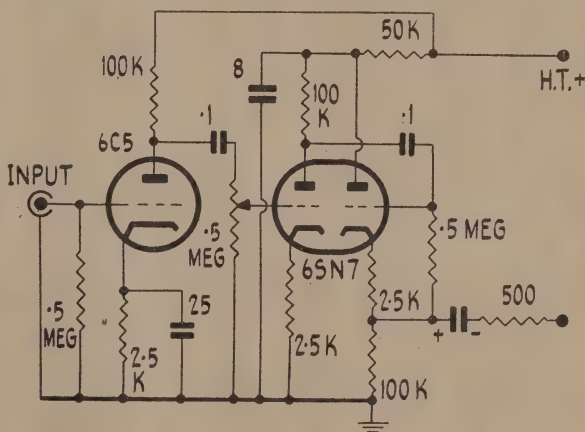
A.P.F., of Auckland, writes asking whether we can solve rather a ticklish problem for him, connected with feeding a crystal pick-up into a rather special commercially-built audio amplifier. The problem is this: The amplifier has three stages, all of which are push-pull, and resistance-capacity coupled to one another. The input is arranged to suit a low-impedance pick-up, which feeds into the primary of the input transformer. This also has the job of providing the phase inversion for the push-pull first stage. The nominal input impedance of the amplifier is thus 150 ohms. A.P.F. wishes to use, as an alternative to the pick-up for which the amplifier was designed, a high-quality crystal pick-up, which will probably, he says, need some frequency compensation. The latter can be expected to reduce the output voltage fairly considerably, so that some extra gain will be needed. How, he asks, is he to accomplish all this, and, in particular he does not want to use a step-down transformer in order to match the input of the main amplifier?

A.P.F. has set us rather a poser! If the pick-up is a high-quality crystal, it will not, even for a start, have anything like the voltage output of the cheaper types of crystal pick-up. Further, if any sort of frequency compensation is to be provided, this will cause a loss of signal voltage at middle frequencies, and will have the effect of considerably lowering the output voltage of the pick-up. All this clearly indicates that some amplification, other than that provided by the main amplifier, will be advisable, if not essential. Now, if this were all, it would be a comparatively simple matter to devise a pre-amplifier which could be coupled to the input terminals of the main amplifier by means of a plate-to-line type of output transformer. This would be the best solution, from the purely technical point of view, and arrangements like this are used every day in broadcast studio equipment, where high-quality transformers of many different kinds are scattered through the gear with what might appear to the amateur as complete abandon. From the amateur's point of view, however, the idea is not a very good one, since transformers of the necessary specification for achieving low distortion and wide frequency response are very expensive. It is doubtless for this reason that A.P.F. wishes us to find some way of doing his job without using a transformer. On the face of it, the proposition looks almost impracticable, and, but for a modern piece of circuitry and the quality of modern components, it would be so in fact.

The diagram shows a way out of the difficulty that we have tried out and found to work admirably. There are certain provisos, however, for the circuit is not everything, but we shall come to that later.

The preamplifier comprises two resistance-coupled voltage amplifier stages. The first is a 6C5 (a 6J5 could be used with equal success), and this is followed by the first half of a 6SN7 (or 6F8-G). The second half of the double tube is used as a cathode follower. The scheme is simply to make use of the power gain of the latter, combined with its low output impedance, to feed the low-impedance primary of the input transformer. Unfortunately, there is a comparatively high D.C. voltage to be found at the

cathode of the cathode follower, and it would never do to apply this directly to the input transformer primary, which was never designed to pass D.C. A blocking condenser is therefore necessary. Unfortunately, again, the impedance on the output side of this condenser is only 50 ohms, so that if the low-frequency response is to be kept up to normal requirements, the condenser will have to be at least 50 μ f. Now, in theory, a paper condenser should be used, so that the D.C. leakage will not be excessive; but in practice it is possible to use an electrolytic! A 50 μ f. 50-volt condenser will hardly be good enough, since the voltage will probably be in excess of 50 volts, so we will have to use a high-voltage electrolytic. In order to reduce by a half the capacity that is needed from consideration of the low-frequency response, a resistor is inserted in series with the output. This has a value of 50 ohms, so that now the condenser need not be greater than 25 μ f. Components of this nature can be obtained, and with very low leakage, especially when they are used on voltages a good deal lower than their rated maximum.



One question that many will want to know is whether or not the circuit introduces too much hum into the output, because of the high heater-cathode voltage in the cathode-follower stage. The answer cannot be definitely given as "yes" or "no," because it all depends on how much hum can be tolerated to begin with. Of course, the usual precautions can be taken to see that such hum as does arise from this cause is not excessive. One advantage of the output series resistor is that the available output voltage is halved by it, thus making the signal level in the cathode follower twice what it would otherwise be. This immediately gives a 6 db. reduction in whatever hum may be present. The pre-set gain control should be set so that the signal passing through the 6SN7 is as large as possible, consistent with not overloading the amplifier proper. This again will help to minimize hum.

No tone control network has been shown in the pre-amplifier, since A.P.F. has not supplied us with any details of what sort of compensation might be necessary, but the gain of the pre-amplifier is approximately 100 times, taking into account the loss in the output coupling. This gives an ample margin for any loss that may be incurred by using an RC type of compensating network. The pre-set control

has been placed between the two stages on the assumption that the output of the pick-up will not overload the first stage. If there is any likelihood of this, the control should be placed at the input to the first stage instead. The best place for a compensation network would be between the pick-up and the first valve, in which case the likelihood of there being enough signal to overload this stage would be so remote as to be negligible, and the gain control could safely be left where it is.

A POINT ABOUT OHM-METERS

"D.C.," of Christchurch, has written to us asking whether we can supply him with suitable circuits for a comprehensive ohm-meter, and sends the following information: "The meter I am using is a 0-100 μ a., with an internal resistance of 950 ohms, approximately. On the resistance range it has a full-scale reading of 500 ohms. The ranges I intend to have are $R \div 10$, $R \times 1$, $R \times 10$, $R \times 100$, $R \times 1000$, and $R \times$ by 10,000."

From "D.C.'s" letter, it is apparent that the meter already has an ohms scale, the one which he states to have a full-scale reading of 500 ohms, and that he is having trouble in making it mean what it says. He gives no other information, such as the manufacturer's recommended circuit, if any, or the voltage of the battery that is meant to be used in order to get the original $R \times 1$ scale to read correctly.

Now, we have published this request in this column because so many people appear to be under a misapprehension with regard to ohm-meters and how they work. Some time ago, we published an article on this very question, and it might be helpful to many of our readers if we emphasize here one very important and easily remembered point. Actually, because "D.C." himself did not realize its importance, the information which he supplied us does not contain enough for us, or for anyone else, to answer. The point is this: **Whatever circuit is used for an ohm-meter, it has, properly speaking, NO FULL-SCALE READING.** This is because, when the meter movement is fully deflected, the reading is either zero ohms or infinity. For instance, take the commonly used series ohm-meter circuit. Here, we have the battery, the meter, and the unknown resistance, all connected in series. To set the zero of the scale, the meter leads are short-circuited, and some extra series resistance used for the purpose is adjusted until the needle is deflected exactly to the full-scale current of the meter. If the latter is a 0-1 ma. movement, the meter reads 0 ohms at the same place as it reads 1 ma. Now, it reads 0 ma. only when no current at all is passing through it. Thus, the resistance connected between the test leads must be infinitely great. **The same thing holds whatever the battery voltage and whatever the sensitivity and resistance of the meter.**

What "D.C." really means when he says that the "full-scale" ohms reading is 500 ohms is that the last division on the ohms scale is 500, which is a quite different thing. If he examines the meter scales carefully, he will find that the 500-ohm mark is close to, but does not coincide with, the zero mark on the current and voltage scales. The reason for this is that, with the battery voltage that is intended to be used for the marked ohms scale, any resistance over 500 ohms gives a reading that is so little different from zero on the current scale of the meter that it is not possible to mark in any higher resistances, both

because, if they were so marked, the accuracy would be very poor, and because there is just no room for them. It will be noticed that the scale is nowhere near linear, and that the marks become progressively closer together the higher the resistance. It is because of this that a number of ranges, in which the basic scale is multiplied or divided by a given amount, is necessary if a wide range of values is to be read on the ohm-meter with any degree of accuracy.

What is not generally known is that any ohms scale can be completely described by stating what the ohms reading is at exactly one-half scale on the meter. Moreover, there will almost always be a division on the ohms scale at this point, because the figure is a round number. For example, if the meter is a 0-1 ma., and the ohm-meter is to use a $1\frac{1}{2}$ -volt cell, the ohms scale will read 1500 ohms at the same place as indicates 0.5 ma. If a simple sum in Ohm's Law is worked out for the series circuit, this can be verified. Taking the above illustration, we know that the battery voltage is 1.5, and that the full-scale reading of the meter is 1 ma. Therefore, when the ohm-meter is adjusted for its correct zero, there must be a resistance R , equal to E/I or $1.5 \times 1000/1 = 1500$ ohms on series with the battery. Otherwise, with the test leads shorted, the meter would not read its full-scale current of 1 ma. This resistance is made up of the resistance of the meter coil itself, plus some extra resistance placed in the circuit. Some of it is in the form of a rheostat, which forms the ohms-zero-adjuster.

Now, suppose we reduce the reading of the meter to 0.5 ma. by connecting a resistor in series with the rest of the circuit. This is done by clipping it between the test leads. The voltage in the circuit is still the same as before, and the current is halved, so that the new TOTAL resistance must be 3000 ohms. But 1500 ohms of this is inside the works of the ohm-meter, so that the added, or "unknown," resistor must have a value of $3000 - 1500 = 1500$ ohms.

Thus, if we work out how much resistance must be put in series with the battery and the meter in order to limit the current to the full-scale reading of the latter, this is the value in ohms which will appear at half-scale on the meter. Taking "D.C.'s" case, and an imaginary battery of 4.5 volts, we find that the half-scale resistance reading would be 45,000 ohms. This shows that the simple series circuit and a battery of 4.5 volts would certainly not give him a basic scale such as he has described, and that a good deal more information is needed. The chances are that the scale he mentions is not the one associated with the basic circuit arrangement at all, but is that of the lowest range intended by the manufacturer of the meter, and for which the movement is shunted so that it really takes 10 ma. or so to deflect it to full scale.

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PICTURE TELEGRAPH EQUIPMENT

(Continued from page 5.)

equipment is as shown in the block diagram. After amplification at its original frequency, and the insertion of a high-pass filter to cut off any unwanted low-frequency components that may tend to come straight through, a frequency changer, after the pattern of the common old garden superhet. mixer, is used to heterodyne the 7,200 c/sec. carrier down to 1,300 c/sec. This done, a high-pass filter is inserted to remove the now unwanted high-frequency components, and the signal is ready for sending down the line to the receiver.

At this point, a further interesting thing arises. The output of the receiver is a variable-frequency tone, varying between 0 and 1,000 c/sec. No attempt is made to re-convert this directly into light intensity variation. The reason for this is partly that, unless a light source like a neon lamp is used, it is not possible to produce rapid enough changes in brightness. For instance, a filament-type electric lamp stores so much heat in its filament that it is not possible to vary its brilliance at anything like a rate of 1000 times a second. This is overcome by converting the frequency variations of the audio output tone into brightness variations, by causing the tone output to vibrate a mirror, which varies the rate at which the light from a lamp of fixed intensity is flashed across a slit. The light which passes through the slit varies in intensity in inverse proportion to the number of times a second that the vibrating mirror flashes it across the slit. Thus, maximum light intensity occurs when the mirror is stationary, and therefore when the modulation frequency is zero cycles a second.

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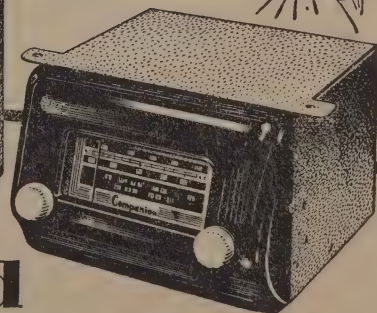
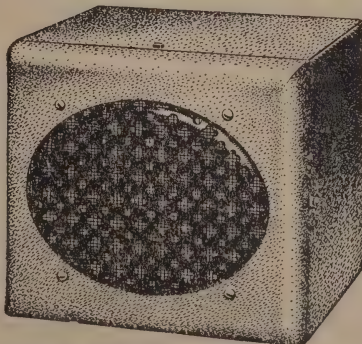
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COMPANION 6-VALVE AUTO-RADIO. Uses specially designed COMPANION inductances to give remarkable performance. Low drain— $4\frac{1}{2}$ amps 6 volt or $2\frac{1}{2}$ amps 12 volt. Retail £35.

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OUR GOSSIP COLUMN



MISS MARY PATON

Girls' Life Brigade, in which she is a lieutenant, is one of her main interests, whilst in sport golf occupies first place in her activities.

Basil Clarkson, of H. W. Clarke, Ltd., after acting the perfect gentleman by pushing a lady driver in her small car through the flood waters in the Wairoa district, found himself similarly marooned. The irony of this position was in no way abated by his seeing the small car and its occupant clear the flood waters and disappear into the distance in all ignorance of the fate of their beentractor, whilst he himself had to spend two of the five hours' wait for help astride the bonnet of his car, soaked to the skin, in the pouring rain. Cold, wet, and miserable, Basil eventually reached Wairoa, where, according to report, half a bottle of the best rapidly assisted his recovery.

Ill-luck, however, still awaited the gallant Basil, whose car, during the return trip to Napier, suffered a broken wheel bearing, necessitating a ten-mile tow. In spite of all his troubles, however, Basil looked little worse for his experiences when relating the

Mr. W. L. Young, manager of Russell Import Co., has just completed an extensive South Island business trip.

Stan Shea, now managing-director of Tele-Communications, Ltd., does not forget old associates, and frequently calls at "Radio and Electronics" for a matter. He says that business is going well and Ian Rowe is doing his stuff. Readers may be interested to know that Stan and Ian left the employ of "Radio and Electronics" some months ago to commence the new firm "Tele-Communications, Ltd.," the address of which is 62 Victoria Street, Wellington.

Ken Stephens, of H. W. Clarke, Ltd., has been host to many visitors of late, including George Pollock, Sidley Wells, Len Hawke, Allan Bayliss, and Henry Cole.

Sponsored by the Royal Society of St. George, 21-year-old Mary Paton is one of the recent entrants in the "Miss New Zealand" quest. A member of the staff of the New Zealand Manufacturers' Federation, who are justly proud of this entrant, Miss Paton was educated at Island Bay School and Wellington Technical College, is keenly interested in public speaking, holds her A.T.C.L., and has gained part of her L.T.C.L. The

Last month Wallace Clarke, managing director of H. W. Clarke, Ltd., made news in the golfing world by being one of the flight winners in the Wellington provincial golf championship tournament at Miramar.

A recent tripper in the North and South Islands for six weeks has been Charles Hart, of National Carbon Pty., Ltd., who informs us that flashlight business was never better, and that radio-set sales are still reaching a high level. Incidentally, the aircraft in which Charles was travelling to Invercargill landed at Christchurch for undisclosed reasons, and the remainder of the journey had to be completed by taxi.

CLASSIFIED ADVERTISEMENT

FOR SALE: ROLA S.12 Speaker, 1000-ohm field; condition as new; £8 or near offer. C. R. Humm, Balmoral Road, Oamaru.

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TRADE WINDS

A.W.A. PRODUCE MIDGET TRANCEIVER

In a sales folder just received from Amalgamated Wireless (Aust.), Ltd., is a description of successful flight tests recently conducted in Australia with a midget tranceiver. In spite of the minute size of the latter (it is no bigger than a cigar-box), the results obtained were phenomenal, proving that signals from distances of up to eight miles could be received with no detectable change in signal strength during turns and other air manoeuvres.

* * *

Just to hand from Philips Electrical Industries of New Zealand, Ltd., is a new brochure entitled "Sound Equipment," describing a comprehensive range of microphones, loudspeakers, and accessories. This will make an extremely useful guide for sound-system projects.

* * *

SOME INTERESTING EXHIBITS

At the Radio Component Manufacturers' Exhibition in London, Standard Telephones and Cables Pty., Ltd., are displaying the following:—

(1) Range of magnetic materials, condensers, quartz crystals, selenium metal rectifiers, valves (including several new types), and a range of coaxial plugs and sockets.

All the above ranges will include components for incorporation in miniaturized equipment. Examples

will represent production samples of proved stability under extreme conditions on working.

(2) Two types of miniature relay never before exhibited, measuring $\frac{3}{8}$ in. x 1 in. x $\frac{1}{8}$ in., requiring coil energizing power of 1 watt, and having coil resistances of from 1 to 2500 ohms. Operating times are from 4 to 10 milliseconds and release times from 2 to 5 milliseconds.

(3) A range of "Jones Type" plugs and sockets.

(4) A new design of high-frequency attenuator in which the control of the pads is by means of push-button switches. It employs cracked carbon resistances and has been tested up to a frequency of 25 mc. and up to an attenuation of 50 db.

There are indications that the attenuator will give a satisfactory performance as regards frequency error at frequencies considerably higher than 25 mc., but difficulties in establishing frequency error by measurement prevent any more definite information being available at present.

The attenuator is made in two "decades" boxes (0 to 90 db. and 0 to 9 db.), giving together a maximum attenuation of 99 db. in steps of 1 or 10 db. respectively.

The attenuator is set up to the required value by pressing the button appropriate to the value of attenuation required. When changing the value, the pressing of the button appropriate to the new value required not only sets up that value, but releases the button previously pressed.

(5) A range of wires and cables, including R.F. and radio-relay types.

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TRANSFORMERS:

230/11v. .75 amp. (Ex1331),	15/- ea.
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230/2v. 14 amp. (Ex1334)	30/- ea.
230/4v. 2.5 amp (Ex1330)	15/- ea.

KLAXON HORNS, 12 volt (Ex1480) 9/11

SWITCHES:

3 position flush charger switch on-off (Ex1385), 1/6 ea.
D.P. 10 amp chrome plate covered porcelain base. (Ex1386) 3/6 ea.
30 ohm variable resistance dimmer switches (Ex1425), 1/- ea.

METAL SHEATH WIRE:

Three wire 40/0076 (Ex1463)	8d. ft.
Three wire 23/0076 (Ex1462)	8d. ft.

TRI-COLOUR NAVIGATION LIGHTS, giving red, green and white, suitable for launches, and tops of caravans, lorries, etc.

(Ex1377), 9/6 ea.

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The PHILIPS Experimenter

An Advertisement of Philips Electrical Industries of New Zealand.

No. 20: FOUR-BAND EXCITER UNIT FOR 80 TO 10 METRES, INCLUSIVE (Concluded) SETTING UP AND OPERATING THE EXCITER

With the coils wound as specified in the last issue of the Experimenter, there should be little or no difficulty about putting the doublers on the correct frequencies. Once the settings have been found for one input frequency which multiplies into all bands, only minor adjustments will be necessary when changing frequency in any of them. However, it is essential to check with an absorption wave-meter whether all doublers are correctly set to the right bands, for it is possible to triple, or even quadruple, in some of them, unknowingly. For instance, it is quite possible, by maladjustment, to have one's output on 42 mc/sec. instead of 30, by unintentionally tripling in the second or third doublers. It will be found that the input circuit, on 80 metres, and the plate circuit of the first doubler, on 40 metres, will tune nearer the high-capacity end of their condensers when the input frequency is near 3.5 mc/sec. The remaining doubler plate circuits will tune nearer the low-capacity end of the condensers.

However, there is only one way in which to set the circuits up properly, and that is with the aid of an absorption wave-meter. If this is not used, there is always some doubt, however small, that the doublers, or at least one of them, may be tuned to a wrong harmonic. We have heard of plenty of people, including ourselves, who have been taken in through not verifying with an absorption meter, in spite of apparently careful work in checking by other means!

ADJUSTING THE COUPLING LINKS

In order to adjust the coupling links properly, it is necessary to have all the grid coils for the straight amplifier stage built. The correct spots on these should also be checked with the absorption wave-meter before anything else is done. One apparently mysterious cause of lack of grid current is that the grid current is tuned to a harmonic of the frequency it is supposed to be on! Having done this, the grid coil for each band should be plugged into its socket, and excitation applied on the appropriate frequency. On 80 metres, it will be remembered, the excitation for the amplifier comes from the V.F.O. direct, and the input circuit of the first doubler does not need to be tuned up for this band. Here, the only adjustment will be in the couplings of the links at the V.F.O. output tank and at the QE04/7 grid coil. It will be possible to get a good 1 ma. or more of grid current, and this is quite enough. Striving for more than this is really a waste of effort.

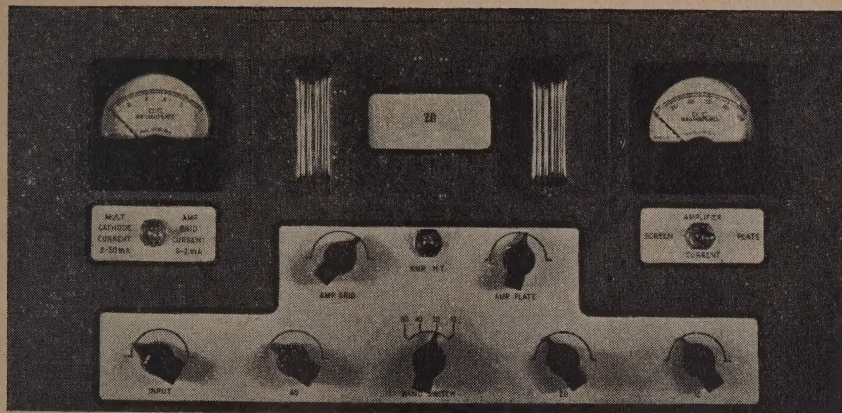
When the 80m. grid coil for the amplifier has been adjusted in this way, the 40m. coil is plugged in, and the exciter switch set to 40 on the wave-change switch. At first, take no notice of the amplifier grid current, and switch the meter to the position where it reads the doubler plate and screen currents. The input circuit is adjusted to the point where a slight flick can be seen on the meter, and set there. The

doubler plate tuning is then adjusted, when a much more pronounced flick will show where resonance is. This brings the doubler input and output circuit near enough for the output to show as grid current when the meter is switched to the amplifier-grid-current position, and the amplifier grid circuit is tuned to resonance. After an indication has been obtained, the doubler input and output circuits can be finally "tweaked" for maximum grid current. If this is less than the required amount, after all circuits are in tune, all that has to be done is to tighten the coupling of either the input link, on the first doubler grid coil, or of the one on the amplifier grid coil, until the required grid current is obtained. Thereafter, the input link to the first doubler is left unchanged, and can be set in position with glue or coil dope.



With the first doubler tuned up and the output coupling adjusted in this way, exactly the same procedure is followed with the second and third doublers. The output of each doubler is adequate to ensure that the next gives more output than the previous one. This situation is aided by virtue of the fact that the EF50's are all working well within their capabilities as to frequency, and gives the exciter the pleasant operating characteristic that there is absolutely no difficulty about obtaining enough drive for the amplifier even on 10 metres. Had any attempt been made to use small receiving valves whose main use is below 20 mc/sec., it would have almost certainly been found that the output became progressively smaller on the higher bands.

With the doublers tuned up and the excitation to the amplifier adjusted on each band, the plate and screen voltage can be applied and the amplifier put into operation. It should be remembered that this is a pentode stage, and that it should on no account be run without load for very long at a time. The reason for this is that, under such conditions, the screen current rises to a much higher value than the rated maximum. The unloaded condition is likely to do permanent harm to the valves if the screen is fed with voltage from a fixed source, but when, as here, the screen voltage is obtained through a drop-



Front view of the completed exciter, showing the 20m. amplifier coil unit in position. The switch between the amplifier tuning controls is to turn off the plate and screen supply while the doublers are being adjusted, or while changing bands.

ping resistor, the heavy current causes the screen voltage to drop well below the rated figure, so that, although the current rating is exceeded, the screen dissipation will not necessarily be. Even so, it is not good practice to allow the stage to be run without a load. Thus, before turning on the plate and screen voltage to the amplifier, it is a wise precaution to couple a dummy load to the output link. The best load consists of a small lamp, such as a 12 or 15-watt car bulb, in series with a variable condenser. If the latter is omitted, it is likely that the lamp will prove highly reactive, so that the minimum plate current of the amplifier does not occur at the setting of the plate tuning condenser which gives the greatest output. The procedure is thne to turn on the H.T. to the amplifier, and tune the plate tank condenser for maximum output. If there is no glow in the lamp, the tank condenser is set instead at the plate current minimum, and the load tuning condenser is adjusted until a glow is seen, and is then set for maximum output. Finally, the tank condenser is re-adjusted for maximum output, which should now occur exactly at the minimum plate current position. If there is much interaction between the two tuning condensers, it is an indication that the coupling is too tight, and that the output link should be moved farther from the tuning coil and the adjustments gone through again. If the new position of the coupling coil allows more power output to be obtained, the original setting was too close. If the load is over-coupled, another indication is the double-peaking common to over-coupled circuits. If the drive has been arranged to give 1 ma. of grid current, it will be found that any increase will not cause the amplifier to give more power output, so that there is no point in trying to get more drive than this out of the multipliers. All one succeeds in doing under these conditions is to cause more grid heating than strictly necessary, thereby shortening the life of the valves.

For those who may have wondered about it, we might mention that the output coupling has been made fixed on the exciter because it is a simpler matter to provide a swinging input coupling link on the final amplifier than to install variable coupling in the exciter. Incidentally, when the exciter is driving a final amplifier, there need be no fear that a reactive load might cause improper operation, since link coupling gives a purely resistive load when both tuned circuits (i.e., at each end of the low-impedance line) are tuned to resonance.

MOUNTING THE AMPLIFIER COILS

The two photographs show how the coils are mounted on the lids of the front compartment. The easiest way to fit the coils to the lid is to leave this until any adjustments have been made and the coils have been fixed with polystyrene dope. Those for each band are plugged in and are fitted with plugs of $\frac{1}{4}$ in. perspex or polystyrene, set into the open ends with cellulose cement, but projecting by a sixteenth of an inch or less. These plugs are then liberally coated with cement and the lid is fitted. This brings the latter hard up against the plugs in the formers, and the cement is left to set. If desired, this fixing can be reinforced with a bolt and nut, through the lid and perspex plug. If this is to be used, it is easiest to bore the holes through the plugs and the lid before sticking the former to the plugs. The hole in each plug is made rather on the large side, so that there is about an eighth of an inch of play all round. This enables the nut and bolt to be inserted, and not quite tightened up, whereupon the cement is put on the inside of the coil-formers, and the edges of the plugs, and the whole arrangement is plugged in, just as in use, and the cement allowed to dry. Finally, the unit is unplugged and cement is run in behind the plugs, between them and the lid, and after plugging in again and drying, course, if one does not mind plugging in two coils the bolts are tightened, completing the job. Of separately each time the band is changed, there is no reason why just one lid should not be made, and the coils left detached in the ordinary way. The complete coil units, however, save much trouble and time in changing bands, and are a great convenience.

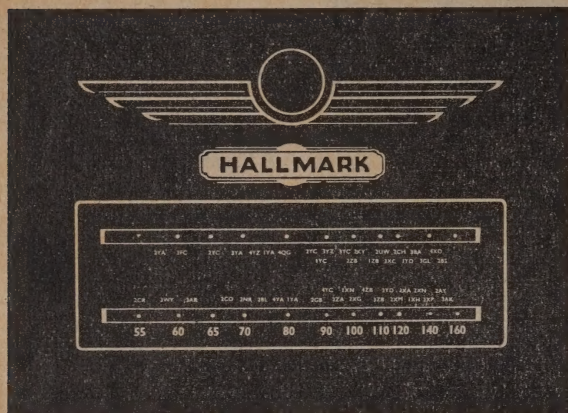
USING THE AMPLIFIER STAGE FOR DOUBLING

If desired, there is no reason why the QE04/7's should not be used as a doubler stage, especially where the full power output that they are capable of as a straight amplifier is not needed for driving the final. Quite adequate operation will be obtained without any circuit changes, and the scheme can be tried when all the amplifier coils have been made, but have not yet been fixed to the lids. All that is necessary is to plug, say, the 40m. grid coil and the 20m. plate coil into their respective sockets, and tune up in the usual way. If this were done, output on all bands could be obtained with the third EF50 doubler omitted.

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G. W. DODDS LTD.

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CONTROLLABLE POWER SUPPLY

(Continued from page 8.)

It is a very simple matter to see by experiment just what output voltage range can be obtained with any transformer that happens to be around, so that the limiting of our data to a single case will hardly matter, especially to the experimentally minded. The circuit will, we think, be found exceedingly useful by many of our readers, especially now that cheap 807's are again available from at least some retailers.

PHILIPS EXPERIMENTER

(Continued from previous page.)

Band.	Form diam.	Turns.	Winding.
80m.	1½ in.	30	Close
40m.	1½ in.	16	1½ in. long
20m.	1½ in.	9	¾ in. long
10m.	1½ in.	3	½ in. long

Input and Output Links

Input and output coils are identical, but spacing is varied as described under "Adjustment."

Band.	Turns.
80m.	4
40m.	4
20m.	3
10m.	2

"R. & E." ABSTRACT SERVICE

(Continued from page 29.)

A Phone-C.W. Transmitter in Miniature. Construction of equipment using miniature components. Designed to operate with nominal power input to final amplifier of 3½ watts. Incorporated features are: All amateur bands covered, from 80 to 6 metres inclusive; phone or C.W. operation by switch control; use of either crystal or carbon microphone; operation from 117-volt line A.C. Unite measures 4 in. x 5 in. x 8 in. Output valve is 12BA6. Modulator valve 50B5.

—Radio News (U.S.A.), March, 1949, p. 49.

VALVES:

A Low-noise Input Tube. Characteristics of 12AY7 valve. Special features are: Excellent signal-to-noise ratio and low microphonics. Valve is a dual-triode. Circuit given for an experimental microphone pre-amplifier using two 12AY7 valves and one 12AU7 in a three-stage, balanced, cross-neutralized arrangement.

—Radio News (Rad. El. Eng. Ed. U.S.A.), Mar., 1949, p. 15.

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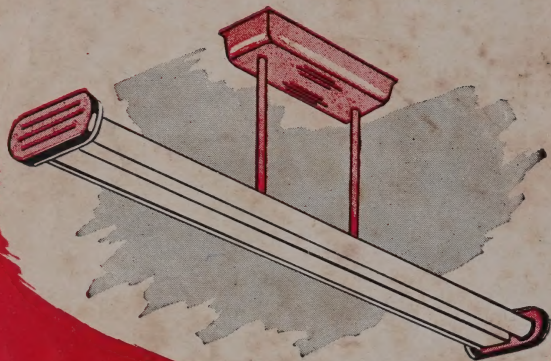
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for old!*

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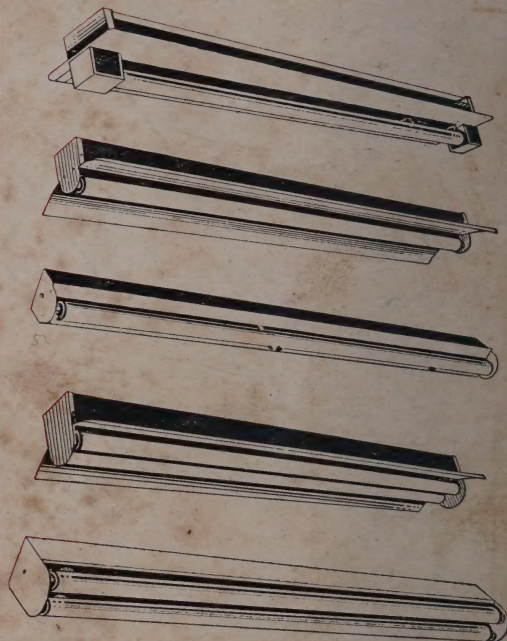
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